

THE ARCHITECTURE OF HIGH SPEED TRANSPORTATION

by

Richard David Rush

Submitted in Partial Fulfillment of the Requirements

for the degree of Bachelor of Architecture

at the

Massachusetts Institute of Technology

January 23, 1967

Signature of Author

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DISCLAIMER

The Appendix A section of this thesis contains only a selection of pertinent pages from the actual proposal made by S.H. Bingham Consulting Engineer. As a result there are deliberate page omissions.

January 23, 1967

Dean Lawrence B. Anderson
Department of Architecture
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Sir:

I submit this thesis, The Architecture of High Speed
Transportation, in partial fulfillment of a Bachelor's
Degree in Architecture.

Sincerely yours,

Richard David Rush

Signed by: Lawrence B. Anderson

Dean of the Department
of Architecture

ACKNOWLEDGMENTS

This thesis was only made possible through the good nature and patience of many people.

Colonel S.H. Bingham (ret.) graciously has supplied the information concerning his proposal for the high speed transit system used in this study.

Professor Donald Appleyard has generously given his time and knowledge especially pertaining to the Modelscope and closed circuit television.

Professor Robert Hanson has provided invaluable information pertaining to Project Metran and transit systems in general.

Mr. Leon Groisser has patiently tried to cope with my ignorance of computer systems.

Professor Maurice Smith was instrumental in giving me the tools to be able to think about Architecture. Who can place enough value on his contribution to my education?

One person stands out as being most helpful to the existence of this project. Mr. Nicholas Negroponte has provided the kind of aid a student needs to be able to cope with his ignorance. This thesis could not exist without his help.

I can only offer my gratitude and hopes that this thesis will justify the help and confidence they so freely supplied.

ABSTRACT

The written portion of this thesis is divided into four major parts. The parts are ordered for convenience of organization and simplicity of comprehension. The first section summarizes the program and attempts to justify it in terms of human experience. Section two explains the background for the specific project of connecting Georgetown Dulles International Airport. The third section attempts to place this project in perspective with the other projects of similar type being conducted around the world. The Appendix covers the abstract material in more detail. Of particular importance is Appendix A which is Colonel Bingham's proposal for the route taken by the transit system. Of equal importance is Appendix D which makes an attempt to clarify the attitude towards simulation techniques.

Part I Thinking about the Program. Phase One

Technology is leaping ahead of today's architects. Also leaping ahead of the imagination is the scale of man's abilities. Architects clearly must expand their abilities through use of tools. Who is going to provide these tools? A tool, like a building, is a design. Every design is only as good as the problem which generates it. Where does the tool designer get his problem? It must come from architects and city planners who both speak the same language as the tool designer.

Normal men have enough problems trying to comprehend simple human speed and scale problems. But man is going to the moon! It is a reality. He has the ability to produce very high speed vehicles. He can travel from Boston to New York City in twenty minutes. Jet planes are here. Jet planes mean many things. They mean that we can travel at tremendous rates. They also mean that today's airports must be modified or rebuilt to handle this new form of transportation.

Dulles Airport, outside of Washington, D.C. is a very important example of jet age design. This airport is huge. It is efficient. It is also far away from the city. This means that it could easily take less time to fly across

country than it does to get home from the airport. Either the jet is too advanced for other forms of transportation and we must accept that fact or we must attempt to bring the forms of land transportation to a speed commensurate with the scale of the jet.

Engineers can and will design any system of this nature. The task of an architect is different. Good architecture and good human experience can not be separated. A good solution to a mechanical problem satisfies an engineer but not an architect; nor does it satisfy the needs of a human being. In addition to being warm, dry, and protected from the sun when he wishes, the human being asks for more. He wants a place in which he can learn. He wants a place which will evoke learning; where human beings can be alone or with others. He wants to be able to work or to play. A human being wants to be alive, all of the time.

Life is either all circulation or no circulation at all. If a man is not alive it is because of powers that are greater than he, or it is because he has decided not to live. Existing and living are just two different things. Man usually does not impose mere existence upon himself. If he does, he is fighting his most valuable state of existence. It is the state of a free and enquiring mind. A mind that is opened. Tools free a man for other things.

A good environment frees a man's mind for other things.

A jet plane is a good example of man's modern dilemma. When he steps into a jet plane he, by choice, must sacrifice various freedoms which are normally his. He is flying at speeds up to six hundred miles per hour at a height of five miles. He can not step out and go for a walk! He cannot open a window. He can only look out of a window. He must generally keep his seat. Assuming he is comfortable in his seat, what does he do with his mind? What do people do in such a situation? They can go to sleep. They strike up a conversation with their neighbor. They pick up a magazine or a book. They can eat or drink. If a man chooses not to read, write, converse, or eat he must satisfy his mind by just sitting and thinking about doing something else. Otherwise, he is forced into a discontinuity of life. What was life, becomes existence.

The plane ride is over. The jet arrives at Dulles International Airport, one of the world's most modern air terminals. He leaves the plane and travels by "mobile lounge" to the terminal. From this point he must either wait for another flight or make arrangements to get to his destination. If he has just flown half-way around the world, it is possible that he might sacrifice great speed for the relief of an open window and the slow speed of an automobile. He might even wish to sit in a comfortable

chair, have a good meal, or finish the conversation which began on the plane. All of these possibilities are presently available at Dulles Airport.

Let us take, however, another example. A business man or diplomat has just spent half an hour in the air from New York City. He has an appointment in the Capitol. He wants to travel as fast as possible. He still does not want to sacrifice his life for his existence. He cannot. In fact he probably wants a reasonable number of choices of activity in transit.

The demand is great. The D. C. Transit company commissions an engineering consultant, S. H. Bingham, to investigate the engineering possibilities for a high speed transit system. The system should be fast and as economical as possible. The transit authorities have also commissioned an architect, Richard Rush, to study the aspects of the new system which pertain to environmental experience. What is the experience of the transit car itself? How does the passenger get to and from the system? Where does he sit to wait for the car? Where does he get a snack if he is hungry? How does he get his baggage to and from the car?

Consider the opposite experience. The diplomat is coming from his office at the Capitol. Can he enter the transportation station, buy a ticket to New York, check his

baggage, and relax while awaiting his train? Can he depart directly from his train into the "mobile lounge" and go directly to his plane? How does this whole system affect Dulles?

As the architect of this project there are several chores that present themselves to me. What kind of spaces are required for waiting, for buying tickets, for refreshment or buying magazines. The station must have light, heat, and warmth. It must be dry and comfortable. If a passenger so desires, he should have the choice to make his experience of waiting a visual one. The architect must begin to think about colors and textures.

The passenger boards the train. But wait a moment. What is the architect is trying to design a continuity of visual experience? What if he is just trying to understand the nature of the trip from the stand point of visual perception? The architect must rely upon his imagination. I am not satisfied. I need a tool. What is available? He has drawings, perspectives, models, photographs of models. But the tool plays an important part in determining the final product. Certainly the more accurate the tool, and the more skillful the artisan, the more precise the result. The architect has the responsibility to himself and his client to be as accurate and as clear as possible.

New tools have been developed for just this kind of

investigation and accuracy. The modelscope, a miniature periscope, has been invented to simulate the experience of walking through an environment in scale model form. This device can be coupled with such devices as a video tape recorder or a 16mm movie camera. At full scale, the movie camera and time lapse photography have been developed, largely by city planners, to simulate moving through an existing environment at various speeds. All of these tools have been developed and are available to the M.I.T. student.

A computer program has been designed to simulate, to a certain extent, the perception of a viewer traveling at various speeds through an environment. This system can, at present be applied to the problem. In the development stages is a computer program known as "Kludge" that will be able to make perspective pictures of an imaginary environment. The unique feature is that this machine is designed so that a novice with normal intelligence can operate it.

The area of study of this thesis is high speed ground transportation. What are the architectural aspects of the problem and what are the possible solutions. Simulation of the experience is an important part of the study. At the very least, some attempt will have been made by an architect to bridge the gap between technological possi-

bilities and the demands of human experience.

A. Phase Two:

- I. Design of a High Speed Transit Station at Dulles Airport.
 - a. Plans and Sections.
 - b. Scale model for Modelscope technique.
- II. Diagrams for design possibilities of smaller stations on the prescribed route.
 - a. Graphical Presentation.
 - b. Block models for simulation technique.
- III. Simulation of a High Speed Transit System through use of motion pictures.
 - a. Movie taken along present highways of the route artificially accelerated to high speeds to simulate the real experience.
 - b. Movie taken with Modelscope of the experience of traveling through stations and into the Dulles terminal in particular.

B. Phase Three: (tentative)

Hopefully phase three will include simulation of the visual aspects of the trip through use of the computer programs being developed by Mr. Negroponte and Mr. Groisser.

Part II History of the Project

A. The Route:

Washington D. C. has an interesting history of attempts to provide a modern transit system. As early as May of 1959 a 116.17 mile monorail system was proposed by the D. C. Transit System Incorporated. This report was admittedly a courageous attempt to thrust a modern transit system onto the city of Washington.

As a result of the initial rather romantic plans of the D. C. Transit System, S. H. Bingham a New York Consulting Engineer was commissioned to do a more detailed study of the whole problem. During this time the Dulles International Airport was under construction. Mr. Bingham's proposal, the one that will provide the basic route for this thesis, was originally prepared as a "Proposal for a Demonstration Model." The plan was rejected by the voters on a bond issue two years ago.

The system has various advantages as stated by the proposal. Some of these which have little to do with criteria previously mentioned. A high speed transit system such as the one proposed will keep the highways free and flexible. This will help to eliminate traffic congestion and strangulation of the city's vital transport means. Also

important is the planning consideration that population and growth generally follows the transportation routes. This is easily understood. The advantages of such a high speed transportation system are summarized in the proposal as follows:

1. High-speed transportation, with a substantial reduction in travel time.
2. Dependable Service
3. Low Cost Service
4. Reduction in highway travel would result in lower capital expenditures for highway construction.
5. Retention of land areas for tax revenue producing development purposes.
6. General tax structure favorably affected.
7. Large increases in land values throughout the area served by the route.
8. The planning and implementation of zoning restrictions are significantly aided.
9. New areas added to tax rolls.

The system and route was largely designed with consideration for the economies of construction and in attempt to provide the most service at least expense. (See Appendix A)

B. Dulles Airport:

It is not the purpose of this study to analyze

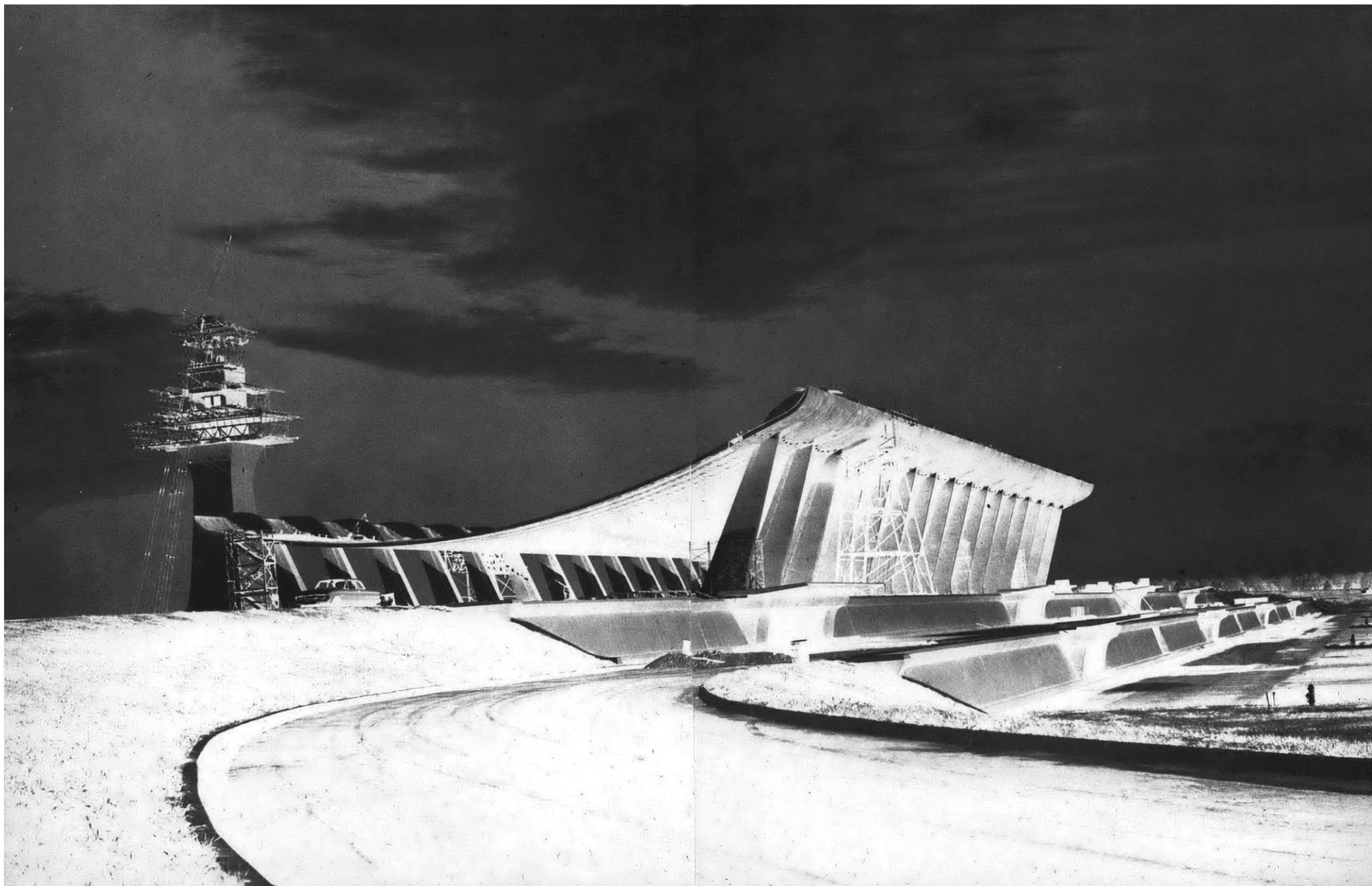
every sort of influence that the monorail or high speed transit systems would have on various building types. Colonel Bingham presents the projected affect that his proposal would have on the population expansion. Also mentioned is the reduction of traffic on the highways and especially in the city proper.

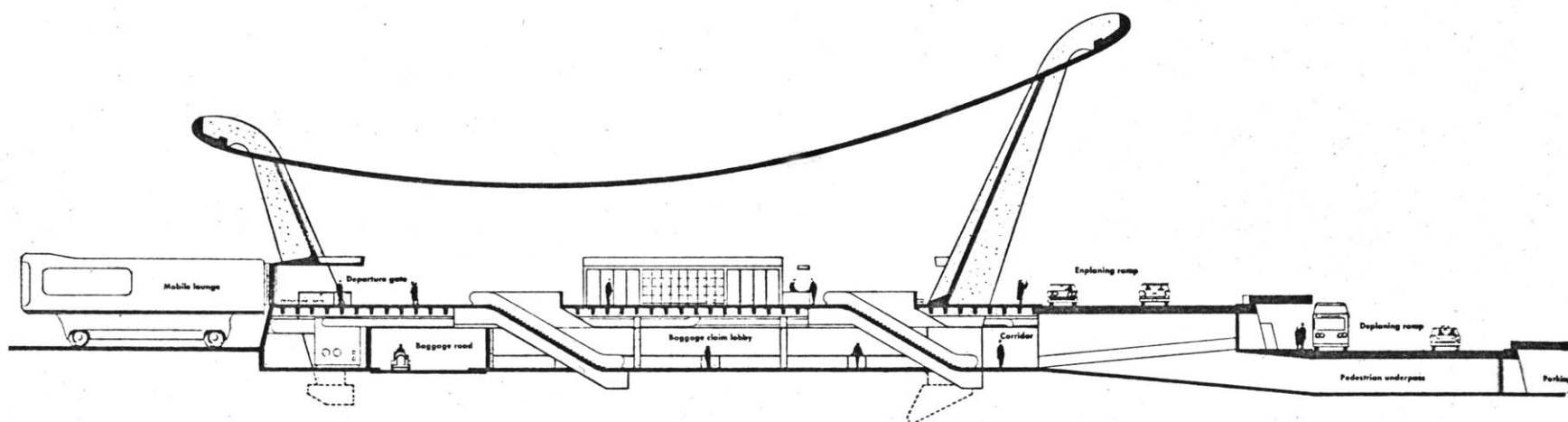
My special concern is the relation that this kind of transportation has with an airport, Dulles Airport in particular. This airport is one of the most modern in the world. It has been designed specifically for use by jets.

Perhaps the most unique feature of this airport is the bus transport system from the plane to the terminal. These are called Mobile Lounges. (See illustration I) The result of this system is a very efficient and fast method of transporting a passenger to the terminal. Once in the terminal the whole function of the terminal can be simplified. All of the airlines can be easily accommodated. There is less duplication of services. The building is linear in plan and means that it can be enlarged easily along its length. The baggage and service floor is carefully separated from the waiting functions. One of the unifying themes of this terminal is simplification and concentration of activity. Any building that would be built near to this one would be expected to work in harmony with it and remain clear. (see drawings)



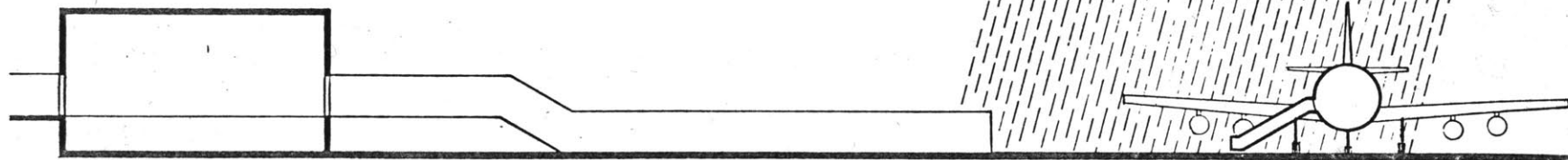
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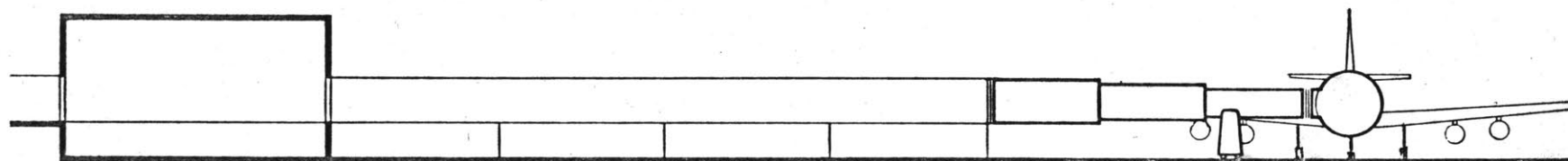


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Old System



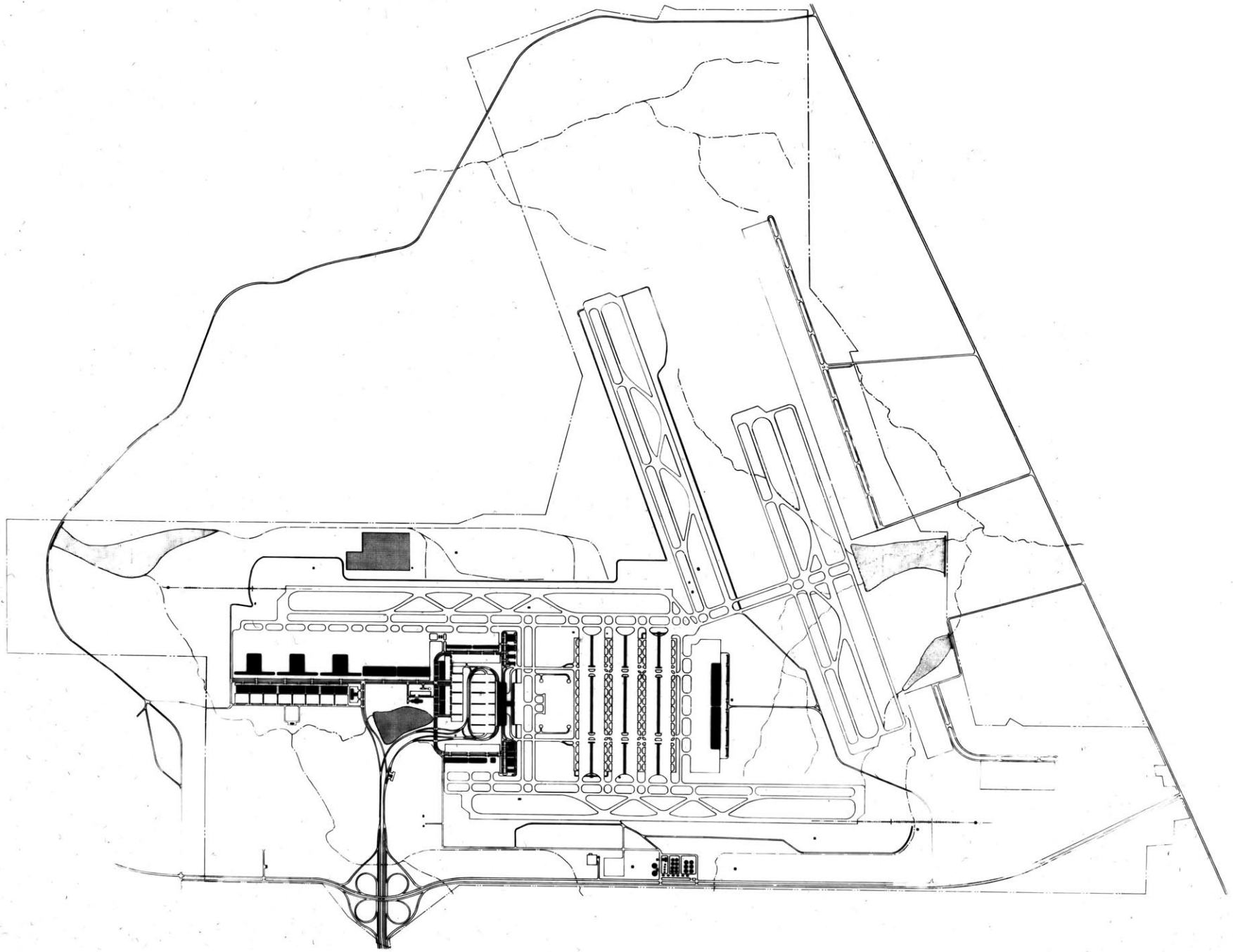
Aero Gangplank on Finger

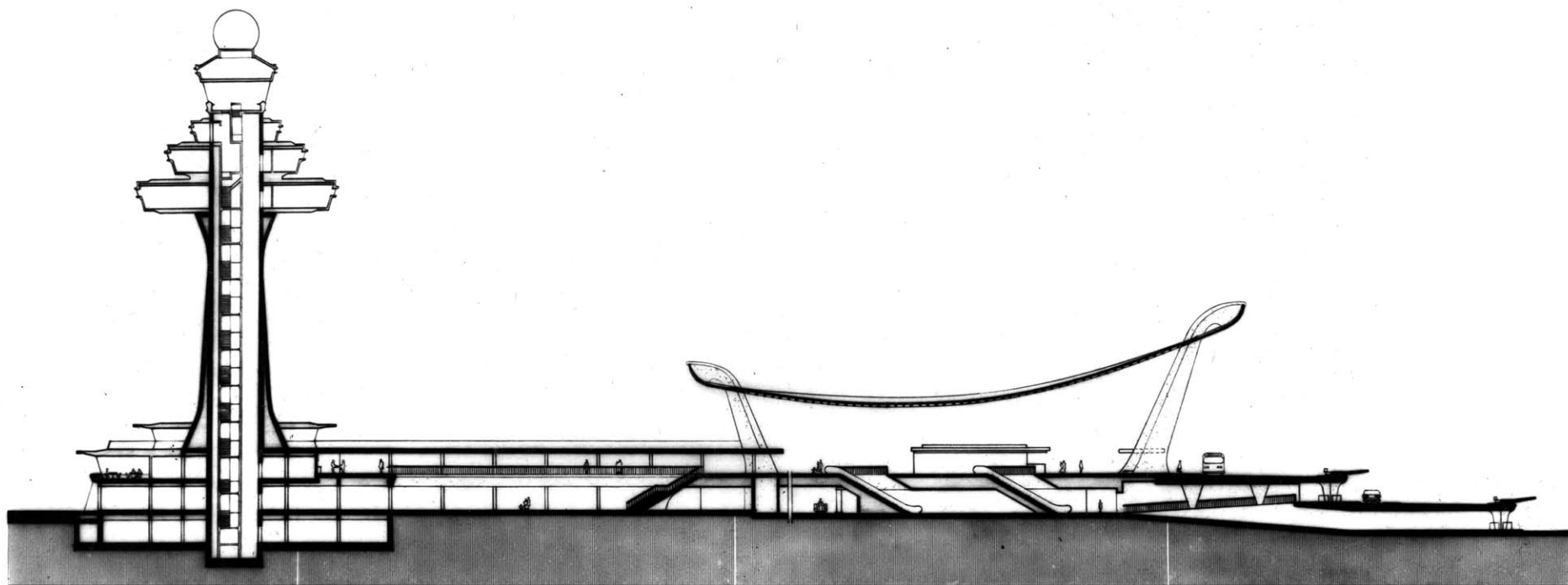


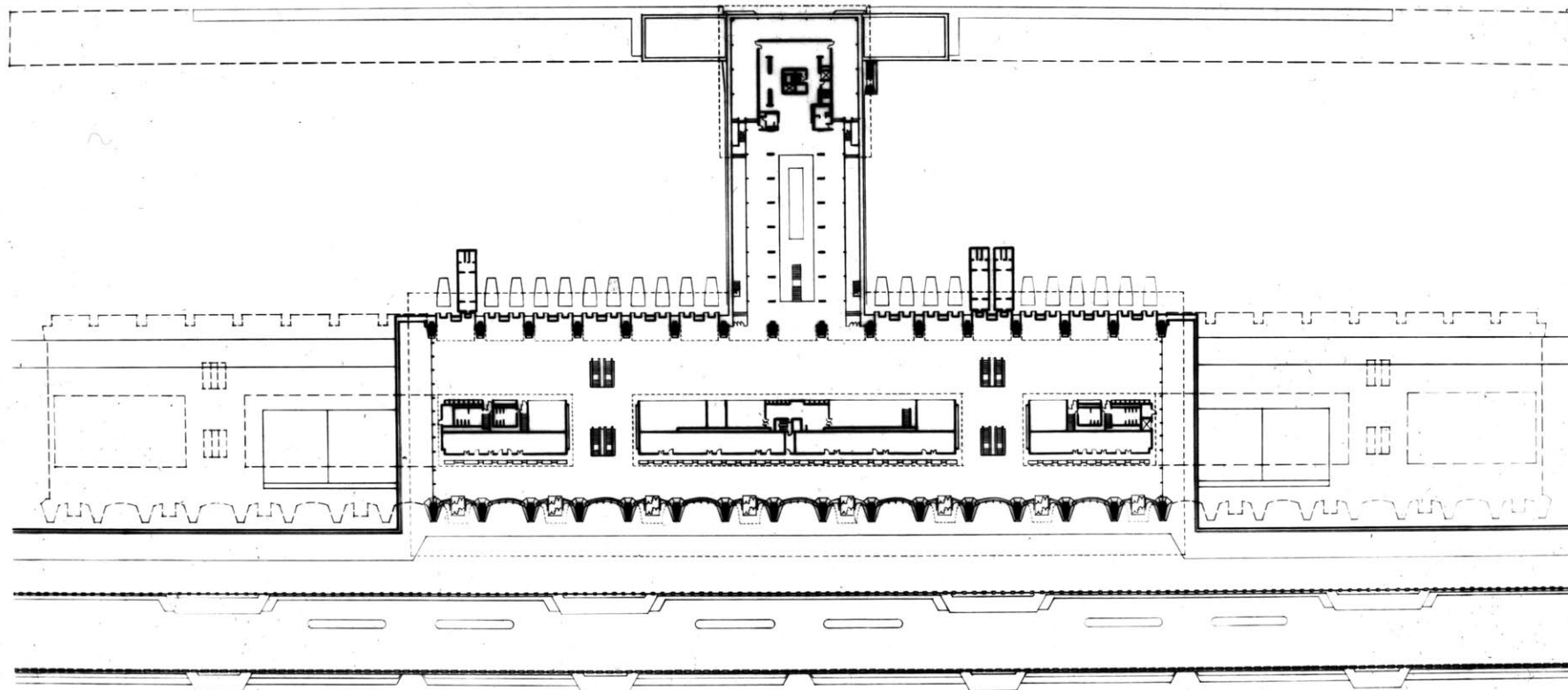
Mobile Lounge System

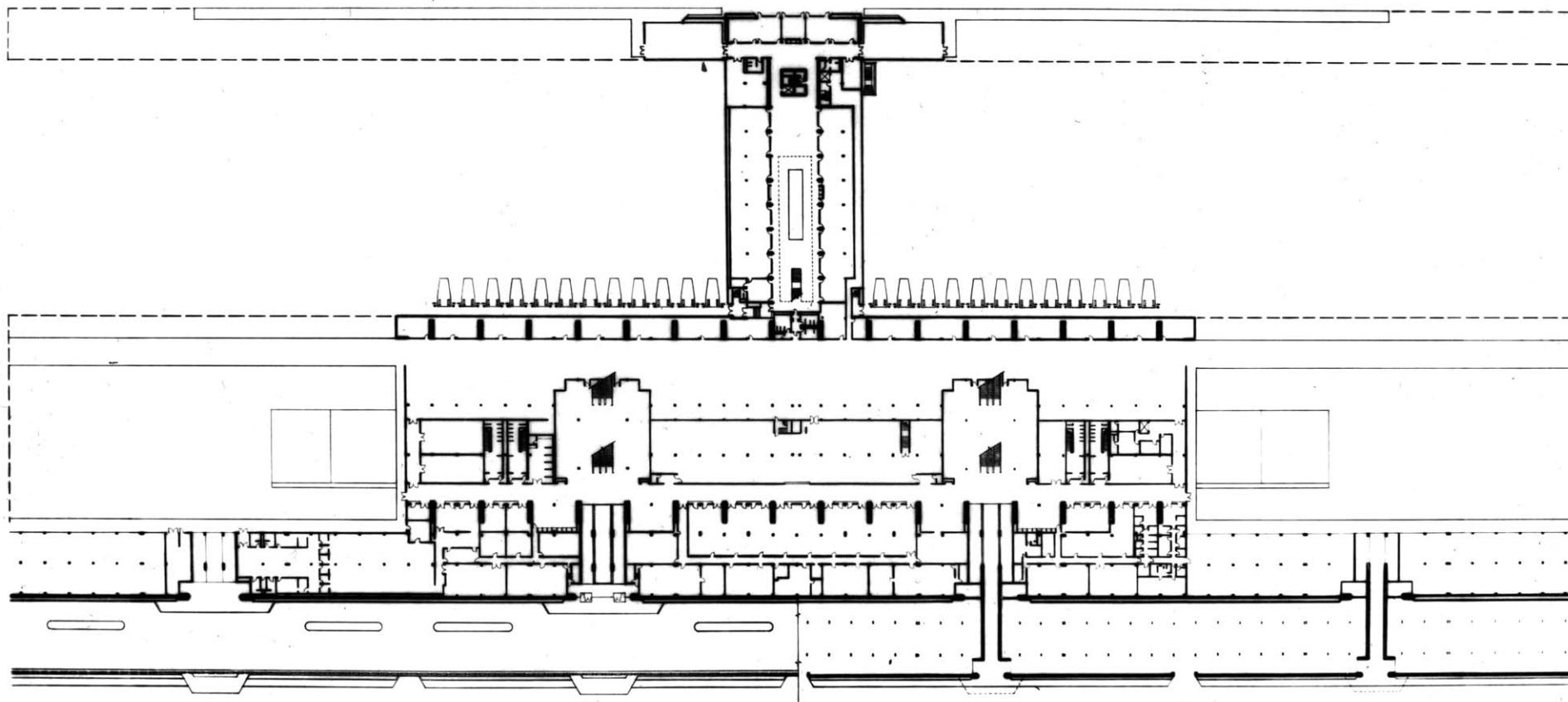


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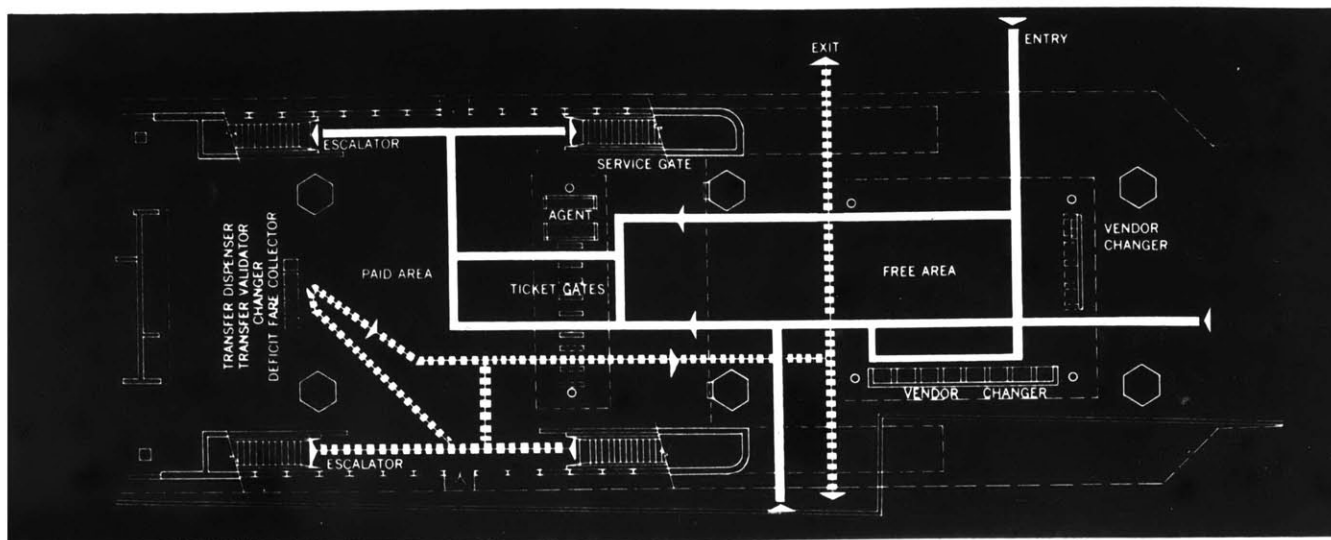
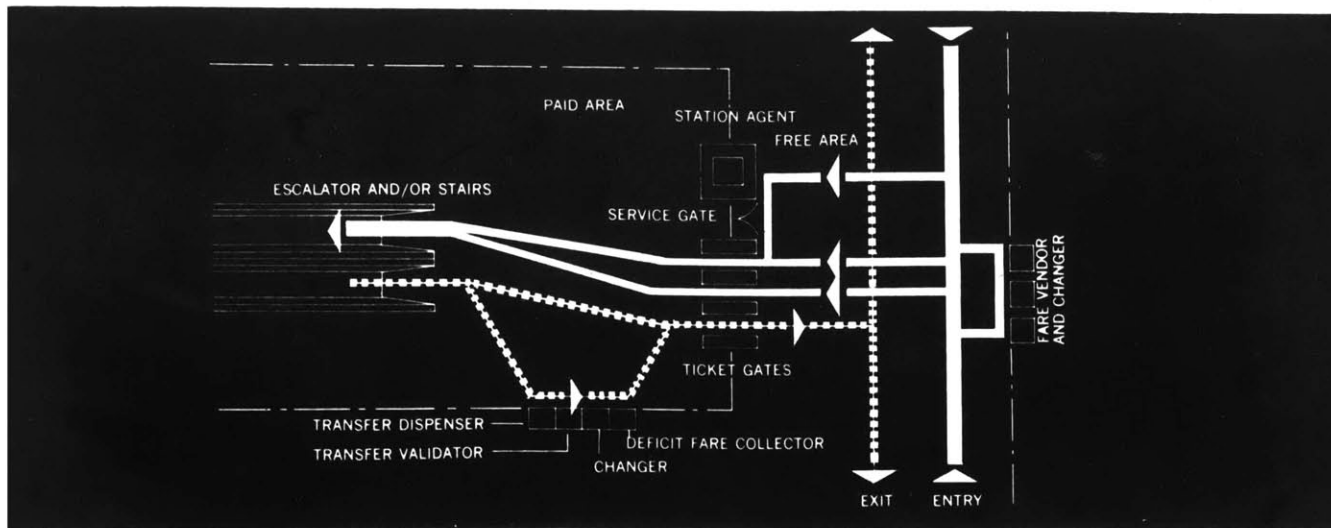




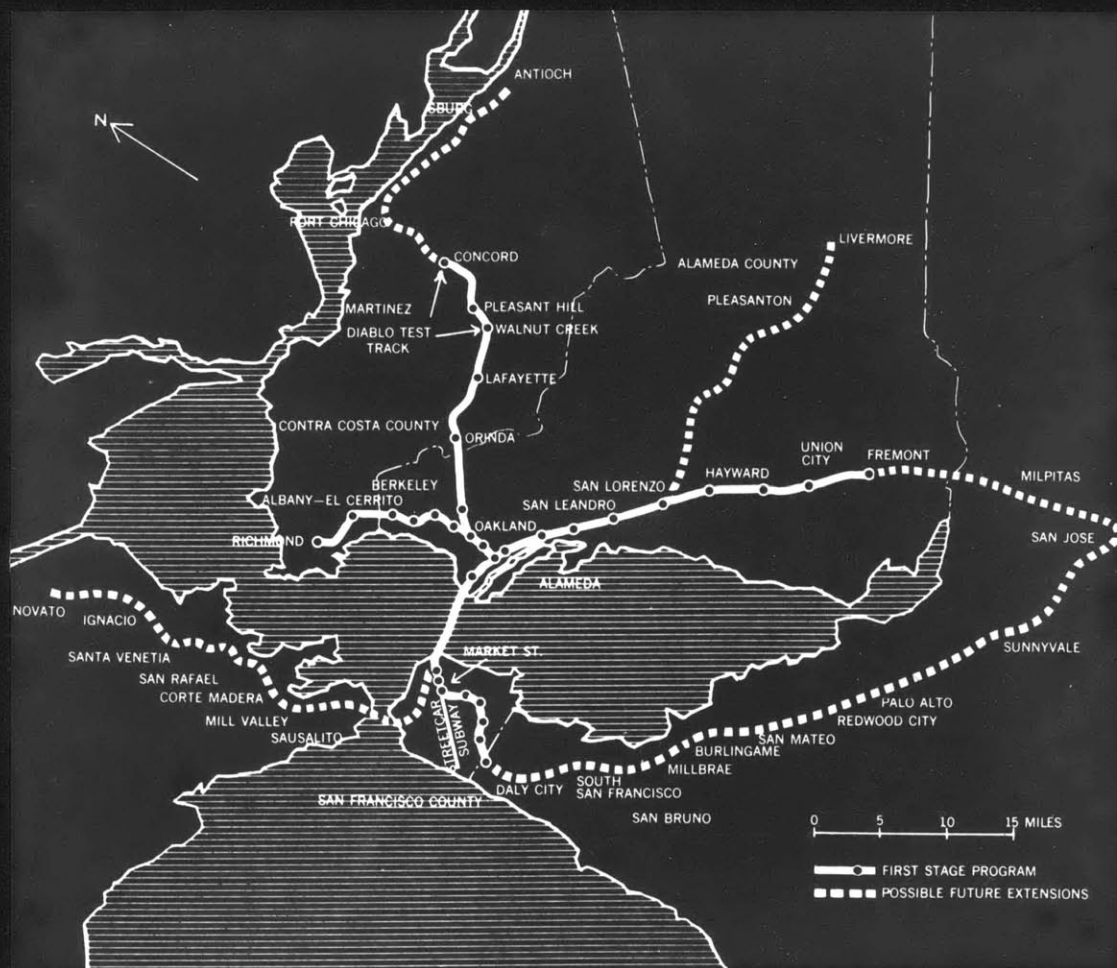
Part III High Speed Transit Systems in Perspective

The reasons for a high speed transit system have been covered thus far to a large extent. I have accepted Mr. Bingham's route as the model for my study. I think I should clarify the issues still more and explain just where this proposal lies in perspective with other transit systems that are being designed throughout the world.

An important project that is now under construction is BART. Bay Area Rapid Transit, in San Francisco. This is a billion dollar project. The entire route covers 75 miles of track and includes transportation at grade, under water tube, tunneling through mountains, and 31 miles of elevated trains. (See illustration II) A special train has been designed that travels through all of these various conditions and at speeds up to 80 mph. Special care has been taken in this project to plan the individual stations. A single architect, Donn E. Emmons, was originally put in charge of this aspect of the project. He and his firm made up a "Manual of Architectural Standards" this document contains 201 pages of specifications which each station must comply with. The individual stations were then commissioned to various firms in the area. Some specifications are clearly applicable to this project and have been presented herein. (See illustration III)



Reproduced from Architectural Forum, June 1966



Reproduced from Architectural Forum, June 1966

The whole project is the obvious predecessor for such a project as the one I am associating with. Clearly the architect has played an important role in the development of BART.

The Japanese have recently spent much time experimenting with high speed monorail systems. The system used in the monorail was the Hitachi-Alweg System. This is the world's longest monorail line. It links Hamamatsucho, in the heart of Tokyo, with Tokyo International Airport at Haneda. The line is 13.1 kilometers in length and has been built largely for the purpose of shortening the one hour automobile trip to a traveling time, by monorail, of fifteen minutes.

Some thought has been given to extending the monorail system which is presently located in the center of Seattle, Washington. The Seattle-Tacoma Airport is nearly ten miles from the center of the city. Careful reports have been made evaluating the existing monorail system by Mr. Eckse of the University of Washington. The presentation is quite clear and complete. It is not clear why the project has not been continued. The immediate reason given is the highway which has been recently constructed from the center of the city to the airport. As has been discussed already, this is only a temporary solution to the problem and relies on old methods that cannot really solve the problem.

Among the various transit systems which have been designed for the same general purpose as the one I am dealing with, much of the work has been done with mono-rails or elevated trains in mind. I believe that the Bingham system is the best that has been developed so far for these purposes. Of special important is the transitional factor of being able to easily combine with the standard form of subway rail transit. (See Appendix B and C)

At even larger distances, greater speeds can be reached. Recently the Japanese have constructed the Tokaido Line, a high speed transit system that encompasses all of the major Japanese cities--Tokyo, Yokahoma, Nagoya, Kyoto, Osaka, and Kobe. The train reaches speeds up to 125 mph and is serving to unite the country into a vast megapolis.

The most recent development has been developed in France by the Engineer-Designer Jean Bertin. This train rides on a cushion of air and, with a jet booster for power, has been tested at speeds up to 250 mph. He has recently made a trip to the United States in hopes of developing a system that could cut travel time between New York and Washington to an hour and a half.

APPENDIX A

The following is a selection of pertinent pages from the actual proposal made by S.H.Bingham Consulting Engineer for the D.C. Transit System.

PROPOSAL FOR A DEMONSTRATION MODEL
of
A CONTROLLED HIGH-SPEED SUPERRAIL
TRANSIT SYSTEM FOR MASS TRANSPORTATION
WASHINGTON, D. C. to DULLES INTERNATIONAL AIRPORT

PREPARED BY D.C. TRANSIT SYSTEM, INC.
WASHINGTON, D.C.

In collaboration with

COLONEL S. H. BINGHAM, (AUS RET.)
CONSULTING ENGINEERS AND ARCHITECTS
NEW YORK, NEW YORK

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D. C. Transit System, Inc. and
Colonel S. H. Bingham, (Ret.)

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ROUTE AND TERRITORY SERVED

The controlled high-speed mass transportation system, details of which are given in this report, would follow a route which has a most advantageous placement in relation to constructional economy and singular utility for public service.

Georgetown-Glen Echo Area

This route, commencing with a tentative terminal in Georgetown, would follow the scenic D.C. Transit right-of-way to the Glen Echo area, a distance of 5.65 miles. Throughout this portion of the route, well-established areas of population would be served. These areas include O.D. zones 17, 16, 13, 12 and 11, which would be directly served, as they border the right-of-way. The bordering zones, 28, 26, 23 and 22, should benefit to a lesser degree from the high-speed mass transit service which the route would provide.

From the Glen Echo area the route would cross the Potomac River to the Government Reserve land near the site of the C.I.A. building. A fortunate factor is the existence of a ravine leading from the southern bank of the river to the higher

land in the governmental area. The existence of this ravine will substantially reduce the cost of construction for this section.

The route in this area would serve the transit needs of the C.I.A. and other governmental agencies which now are, or will be, established in this Reserve land.

The McLean Area

The route would then continue over the median strip of the McLean bypass to the growing community of McLean, which it would effectively serve. The route distance from the Glen Echo area to McLean is 4.50 miles.

Dulles International Airport

From McLean the route would follow the median strip of the Dulles International Airport access highway, a distance of 15.75 miles, a total length of route from Georgetown to the Airport of 25.90 miles.

Between McLean and the Dulles International Airport, the route would be a vital factor in the vigorous economic growth of the numerous development enterprises which today are reported to be in various states of planning.

The terrain is favorable to construction of the system; the crossing of the Potomac River presents no engineering problem of moment.

Throughout the land areas traversed, long sections of the route are essentially tangential; wide radius curves are possible where such design treatment is necessary. Maximum grades, mostly of very short duration, are not expected to exceed 4 percent. Such gradients are limited in number and readily negotiable.

A most important and economically attractive feature which greatly favors construction of this proposed demonstration model of a controlled high-speed mass transit system is that its construction would involve no purchase of property, no easement, and no property condemnation. Consumation of the project would be dependent upon agreements mutually negotiated between all the governing agencies involved and the responsible proponents of the proposed system.

Extensions and Additions

Washington, D. C., the Nation's Capital, is also the Nation's showcase and warrants the most modern and progressive installations. The controlled high-speed mass transit

system presented herein is not limited to the Dulles International Airport route as an isolated installation. Its economic and utilitarian merits justify its serious consideration in a greater field of application.

Numerous streets and highways in the District of Columbia are provided with median strips which lend themselves admirably to the rapid construction and operation of this transit medium. An extensive system of high-speed mass transit facilities is therefore possible over existing streets and highways with no new roadway construction necessary. These street and highway corridors serve the areas of major population density, - the areas, therefore, in greatest need of high-speed mass transportation.

The constructional economies which the principle of overhead Superrail operation makes possible are coupled with a capability for underground placement, in specific and limited areas where compelling circumstances are believed to exist.

Established Communities

The route as outlined in Chapter II traverses a tributary area containing a number of existing community centers, the growth of which would be stimulated by the availability of a controlled high-speed mass transit system. These are:

1. The Georgetown-Glen Echo Area
2. The Government Reserve Land-C.I.A. Building
3. McLean and environs
4. Herndon and environs

Population Growth Trends

1. The Georgetown-Glen Echo Area

That portion of the route which follows the scenic D.C. Transit right-of-way from Georgetown to the Glen Echo area in Maryland, passes through corridor O.D. zones 17, 16, 13, 12 and a portion of O.D. zone 11. The route also lies in close proximity to O.D. zones 28, 26, 23 and 22, which border the corridor O.D. zones. The corridor O.D. zones 17, 16, 13, 12 and 11, and to a lesser extent the bordering zones, were the areas which provided the riders for the street car operations.

These annual totals are equivalent to an attendance during a six-month season of 20,000 per day in 1965 and 40,000 per day during 1980.

In the evaluation of these totals, consideration must be given to the fact that during 1965 an estimated number of 10,300,000 and in 1980 an estimated number of 14,300,000 visitors of all categories will visit the Nation's Capital. A large percentage of these are in "holiday" mood.

The existing Glen Echo Amusement Park attracted approximately one million visitors over a five-month period during 1960, or approximately 7,000 per day.

Dulles International Airport

The operation of a modern airport requires a multitude of activities which involve people who have considerable diversity of interests. These may be classified as follows:

- (a) Passengers
- (b) Visitors accompanying or meeting passengers
- (c) Employees
- (d) Sightseers
- (e) Mail Trucks
- (f) Supply Trucks

In any determination of the percentage of airline passengers who might wish to patronize the controlled high-speed mass

transit system it is necessary to consider them in certain group classifications, as follows:

- I. Local - Those who originate or terminate in the Washington, D.C. area.
- II. Transfer - Those who transfer to other planes at the Dulles International Airport.
- III. Those who use the Dulles International Airport as a stopping point en route to and from other destinations only because their aircraft makes a stop there.

Group I, therefore, is the prime source from which patrons of the high-speed mass transit system may be attracted.

In quite a limited way, Group II could provide some patronage. It is considered appropriate, however, to regard Groups I and II as constituting the total outgoing or incoming passenger population.

Experience has shown that an airport which handles approximately 7,500 arriving and departing passengers on a typical day can be assumed to have about 3,700 visitors and sightseers and 3,500 employees.

It has been estimated that the growth of traffic at the Dulles International Airport will involve the following totals of enplaning and deplaning passengers:

TABLE NO. 8

Dulles International Airport
Estimated Yearly Passenger Volumes

	<u>Domestic</u>	<u>International</u>	<u>Total</u>
1st year	1,265,000	305,600	1,570,600
5th year	2,235,600	384,000	2,619,600
15th year	5,525,000	580,000	6,105,000

If it is assumed that the Dulles International Airport will commence operations in 1962, the projected values for total passengers, employees and visitors would be as follows:

TABLE NO. 9

Dulles International Airport
Projected Yearly Passenger Volumes

	<u>1965</u>	<u>1980</u>
Domestic	1,855,000	5,525,000
International	<u>352,640</u>	<u>580,000</u>
Totals	2,202,640	6,105,000

These values indicate an estimated average traffic volume at the Dulles International Airport of 7,500 daily passengers

in 1965 and 20,000 daily passengers in 1980.

TABLE NO. 10

Estimated Number Of
Daily Occupied Airport Employees

<u>1965</u>	<u>1980</u>
3,200	10,000

TABLE NO. 11

Estimated Average
Number of Daily Visitors and Sightseers

<u>1965</u>	<u>1980</u>
3,000	9,500

With the use of the jet airplane, distant cities can be reached within minutes or hours, and air speed capabilities are still in the development stage. Completely out of harmony, and to a degree nullifying the speed advantages otherwise gained, existing means of ground travel to and from the airports present a picture of frustration. In many instances the time consumed in ground travel to and from airports equals the time spent in flight.

The high-speed mass transit system herein discussed would connect the airport and the central city in approximately

25 minutes running time compared to a required time by existing media of transit estimated to be in excess of 45 minutes.

Air Mail and Airborne Parcel Post

A potential source of revenue for this demonstration model of controlled high-speed transit would be developed through the transport of mail, parcel post and other related services between the airport and a mutually acceptable location.

Cars of special design will be provided for this purpose and will permit pallet and basket types of mail containers to be carried. Related commodities which have miscellaneous classifications may also be moved.

Advertisements and Concessions

Traditional forms of revenue for transit vehicles and station areas which would be sources of revenue for the controlled high-speed mass transit system are advertisements and concessions.

Visitors, Conference and Convention Attendance

Washington, the National Capital, is a powerful magnet which draws visitors from all over the nation and points

beyond. In addition to its annual influx of tourist visitors, it also acts as a host city to numerous conferences and conventions. Their potential as patrons of the controlled high-speed mass transit system is extremely high. Available figures on the annual totals of these groups are quite accurate.

These statistics show the following totals for 1960. Projections of estimated rate of increase to 1980 are included:

TABLE NO. 12

Annual Visitors to the National Capital

	<u>1960</u>	<u>1965</u>	<u>1980</u>
Delegates to Conferences and Conventions	450,000	550,000	750,000
School Students	600,000	800,000	1,200,000
Sightseeing Visitors	<u>6,200,000</u>	<u>8,950,000</u>	<u>12,350,000</u>
	7,250,000	10,300,000	14,300,000

Summation of Mass Totals

A summation of the segregated population totals contained in the preceding tables, reveals, in effect, the mass total or population pool from which the revenues of the controlled high-speed mass transit system would be derived. The summation

TABLE NO. 14

ESTIMATE OF PROSPECTIVE PATRONS
DAILY SINGLE TRIPS
1965

	<u>Population</u>	<u>Family Unit</u>	<u>Labor Force</u>	<u>Single Trips</u>	<u>Total Daily Trips</u>	<u>Estimated Patronage</u>	<u>Estimated Number of Passengers</u>
1. O.D. Zones 17-11	73,300 ÷	3	= 24,500 x	2 =	49,000	12%	5,880
2. O.D. Zones 28-22	91,800 ÷	3	= 30,000 x	2 =	60,000	2%	1,200
3. Glen Echo Amusement Park	1,150,000 ÷	150	= 7,500 x	2 =	15,000	15%	2,250*
4. Government Reserve and C. I. A.			= 10,000 x	2 =	20,000	20%	4,000
5. McLean	21,200 ÷	3	= 7,000 x	2 =	14,000	15%	2,100
6. Herndon	15,000 ÷	3	= 5,000 x	2 =	10,000	20%	2,000
7. Educational Recreation and Exhibition Park							
a. Local Visitors	1,800,000 ÷	180 days	= 10,000 x	2 =	20,000	20%	4,000**
b. Visitors to National Capital	1,800,000 ÷	180 days	= 10,000 x	2 =	20,000	65%	13,000**
8. Airport - Passengers	2,202,640		7,500 per day			40%	3,000
9. Airport - Employees			3,200 x	2 =	6,400	16%	1,020
10. Airport - Visitors			3,500 x	2 =	7,000	30%	2,100
11. Visitors to National Capital							
10,300,000 minus 1,800,000 annually							
or 28,000 per day x 2 = 56,000 average						65%	<u>36,000</u>
							76,550
Basis: 300 days all items except 3 and 7a. and b.							
57,300 x 300 days =					17,190,000		
Basis: 150 days - item 3							
2,250 x 150 days =					337,500		
Basis: 180 days - item 7a. and b.							
17,000 x 180 days =					<u>3,060,000</u>		
Total annual single trips					<u>20,587,500</u>		

* Deduct 337,500 if an educational recreation and exhibition park is in operation.

** Deduct 3,060,000 single trips if an educational recreation and exhibition park is not in operation.

TABLE NO. 15

**ESTIMATE OF PROSPECTIVE PATRONS
DAILY SINGLE TRIPS
1980**

	<u>Population</u>	<u>Family Unit</u>	<u>Labor Force</u>	<u>Single Trips</u>	<u>Total Daily Trips</u>	<u>Estimated Patronage</u>	<u>Estimated Number of Passengers</u>
1. O.D. Zones 17-11	90,700	÷ 3	=30,000 x	2 =	60,000	15%	9,000
2. O.D. Zones 28-22	100,100	÷ 3	=33,000 x	2 =	66,000	2%	1,320
3. Glen Echo Amusement Park	1,450,000	÷ 150 days	= 9,666 x	2 =	19,400	15%	2,900*
4. Government Reserve and C.I.A.			=20,000 x	2 =	40,000	20%	8,000
5. McLean	32,000	÷ 3	=11,000 x	2 =	22,000	15%	3,300
6. Herndon	80,000	÷ 3	=27,000 x	2 =	54,000	25%	13,500
7. Educational, Recreation and Exhibition Park							
a. Local Visitors	3,000,000	÷ 180 days	=17,000 x	2 =	34,000	20%	6,800**
b. Visitors to National Capital	4,200,000	÷ 180 days	=23,500 x	2 =	47,000	65%	30,500**
8. Airport	6,105,000 annual			daily	20,000	40%	8,000
9. Airport - Employees					20,000	16%	3,200
10. Airport - Visitors					20,000	30%	6,000
11. Visitors to National Capital							
14,300,000 minus 4,200,000 (included in educational recreation and exhibition park) = 10,100,000 annually or 33,700 daily						65%	<u>21,900</u>
							114,420
Basis: 300 days all items except 3 and 7a. and b.							
74,220 x 300 days =					22,266,000		
Basis: 150 days - item 3							
2,900 x 150 days =					435,000		
Basis: 180 days - items 7a. and b.							
37,300 x 180 days =					<u>6,714,000</u>		
Total annual single trips					29,415,000		

* Deduct 435,000 single trips if an educational recreation and exhibition park is in operation.

** Deduct 6,714,000 single trips if an educational recreation and exhibition park is not in operation.

TABLE NO. 16CONDITIONS OF OPERATION AND CAR REQUIREMENTS

Daily Passengers	
Single trips one-way	38,275
Maximum Hour	
15 percent of 38,275*	5,740
Car Capacity - Passengers	100
Maximum hour train trips necessary with 4-car trains	15
Headways - Minutes	4
Number of cars required	60
Spare cars required	5
15 train trips x 400 passengers per trip =	6,000 passengers
15 train trips x 4 cars per train =	60 cars
15 train trips with 4 minute headways =	60 minutes

* The volume of passenger movement during the maximum hour has been estimated as representing 15 percent of the one-way total of 38,275 or 5,740 passengers. This system, with the full safety protection provided by the modern signal system, is capable of carrying 45,500 passengers per hour in each direction with 10-car trains operating at 2-minute intervals. The system is also capable of operating at 90-second intervals if required.

the train schedule, the automatic dispatcher will select the train to be dispatched, the route over which the departing train must operate, set the route, switches and signals, illuminate the starting lights, close the doors and start the train.

Each station will have a programmer that will regulate the length of station stops, in accordance with the time of day, depending on whether it is rush hour, evening, non-rush hour, etc.

As the train approaches a station, it will be brought to a safe predetermined speed and the head end of the train will stop at a preselected point, plus or minus 3 feet.

Departure time will be indicated by an audible alarm and the doors, which are interlocked with the controller, will be closed automatically permitting the train to proceed on its way.

As previously mentioned, the supervisory control system is combined with the signal system to form a single system.

The supervisory control is subjected only to local conditions without any consideration of conditions that may prevail on any other part of the railroad or route control system.

STATIONS AND PARKING AREAS

Station Locations

The proposed route would be provided with two terminal stations and five intermediate stations, making a total of seven.

A tentative inner terminal station would be located in Georgetown; the outer terminal station would be located at Dulles International Airport.

The five intermediate stations would be located in the following areas:

Brookmont
Glen Echo
C. I. A. Area
McLean
Herndon

Station Arrangements

The general arrangement and appearance of the stations are shown in Fig. 7, Fig. 8 and Fig. 9.

A mezzanine floor, beneath the platform area, would be reached from street level by passageways on both sides of the highways.

The mezzanine floor would accommodate the necessary facilities for change making, turnstiles and public comfort rooms. The platforms overhead would be reached by speedwalks and stairways.

It is considered that an island type platform would most effectively serve this controlled high-speed mass transit operation. These platforms would be provided with weather-proof enclosures for the protection of waiting passengers during inclement weather.

The exposed sections of the platforms would be covered with structural, protective canopies of modern design.

Provision has been made in the cost estimates for platforms having a length of 300 feet, which would permit the operation of trains with consists of five 50-foot cars. The design of the platforms permits extensions to be added as the need develops.

Station Lighting

The mezzanine and platform areas would be illuminated by fluorescent lamps using a continuous strip-type of fixture. These would provide an illumination level for these areas of not less than 20-foot candles.

Station Advertising

Revenue-producing advertising displays would be made possible through the provision of suitable panels on appropriate wall spaces within the mezzanine and platform areas.

Terminal Stations

The terminal station at the Dulles International Airport would be located and constructed in accordance with the regulations of the governing authorities.

As a service of public convenience, it is highly desirable that this station should be located in close proximity to the main concourse of the airport terminal building. If such an arrangement should gain favor it would be possible to operate the train into the terminal building at a below-ground level.

From the platforms, speedwalks would carry the passengers directly into the main concourse of the airport terminal building.

Automobile Parking Areas

The provision of automobile parking areas at station locations has proved to be an effective means of increasing

the usage of public transit facilities. This so-called "park and ride" convenience is becoming increasingly popular and will be made available wherever possible. In addition to this, the drive and ride practice is growing in importance as a revenue producer, particularly throughout such comparable areas as those considered for this route.

In a drive and ride operation, the transit passenger is driven to or met at the station by a member of the family using an automobile. This is attractive to the transit rider as it provides him with a speedy ride to his destination and it makes the automobile available to the family during the day.

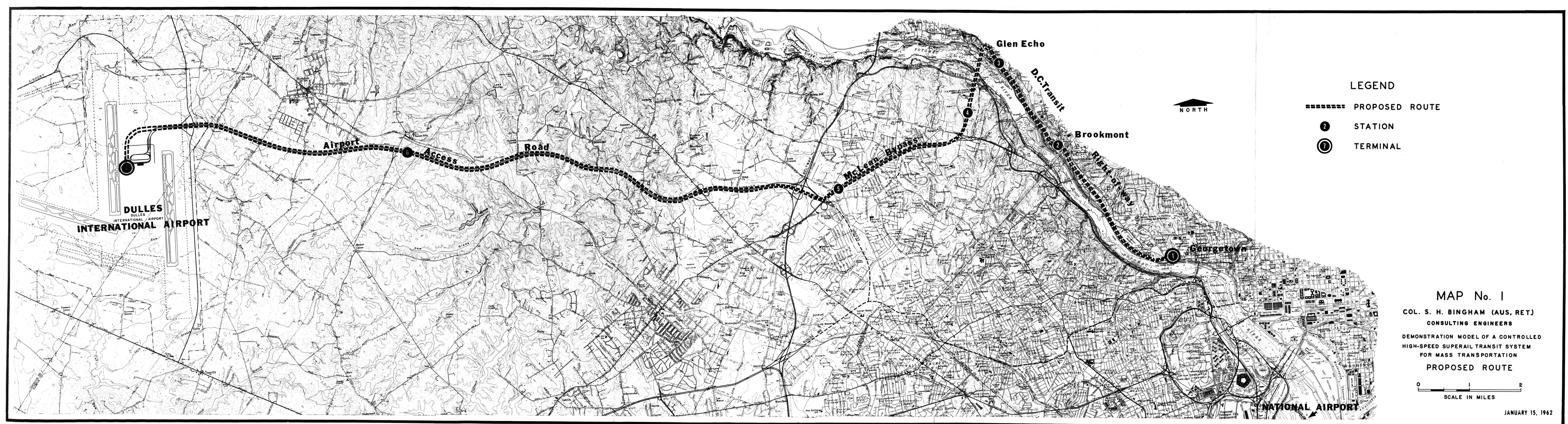
Local Feeder Buses

In order to increase the revenue from areas beyond walking distance of the Superail transit stations, a system of feeder buses has been considered. The provision of routes and vehicles to serve the areas in the vicinities of the enumerated stations is a matter of planning.

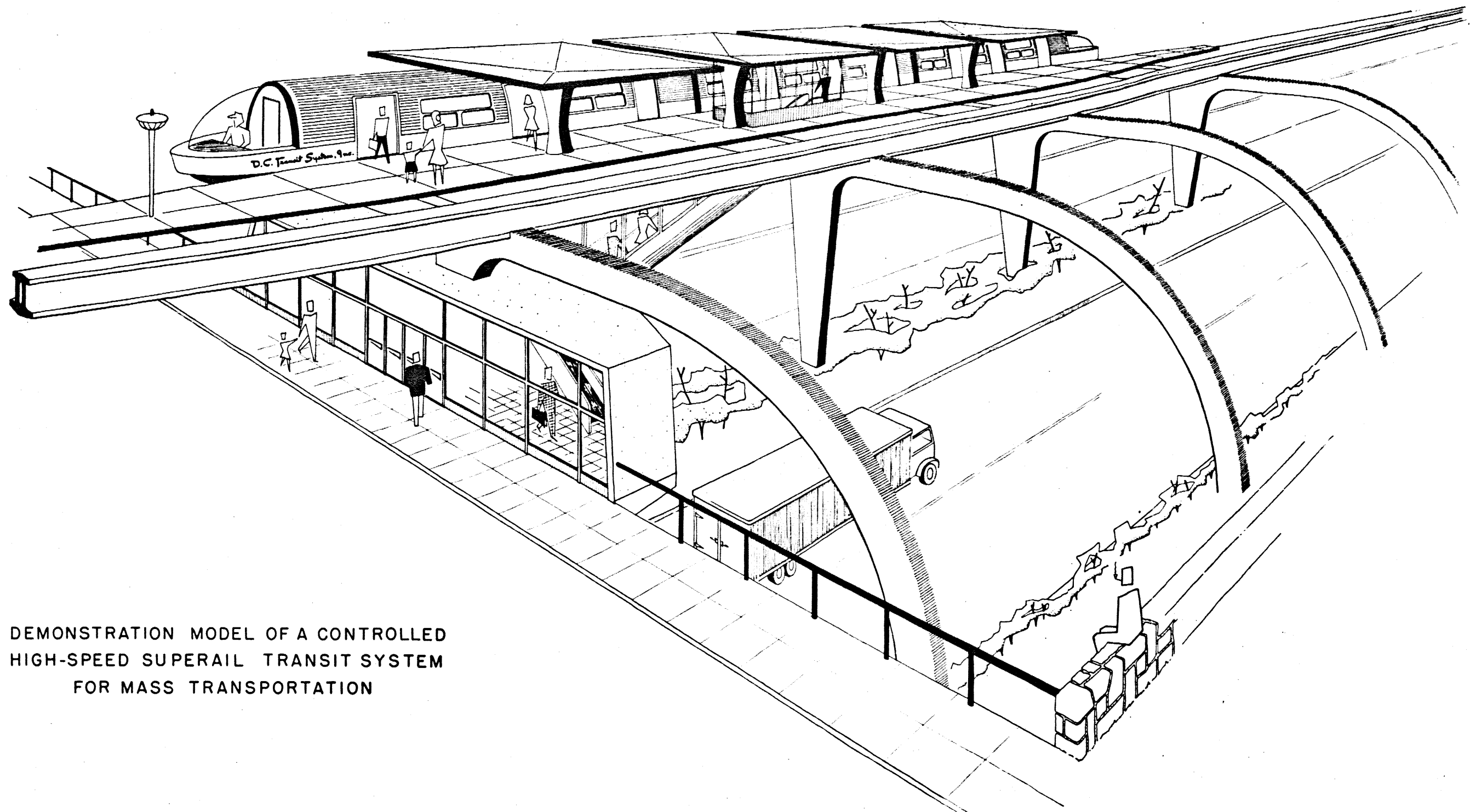
Feeder Buses to Central City Area

Until the controlled high-speed mass transit system is extended into the central city area it will be necessary to operate a

feeder bus service between the tentative terminal at Georgetown and a designated area or areas in the central city. Cost estimates for this operation have been included in the estimated total costs.







DEMONSTRATION MODEL OF A CONTROLLED
HIGH-SPEED SUPERAIL TRANSIT SYSTEM
FOR MASS TRANSPORTATION

PERSPECTIVE OF A TYPICAL WAYSIDE STATION

FIG. 7

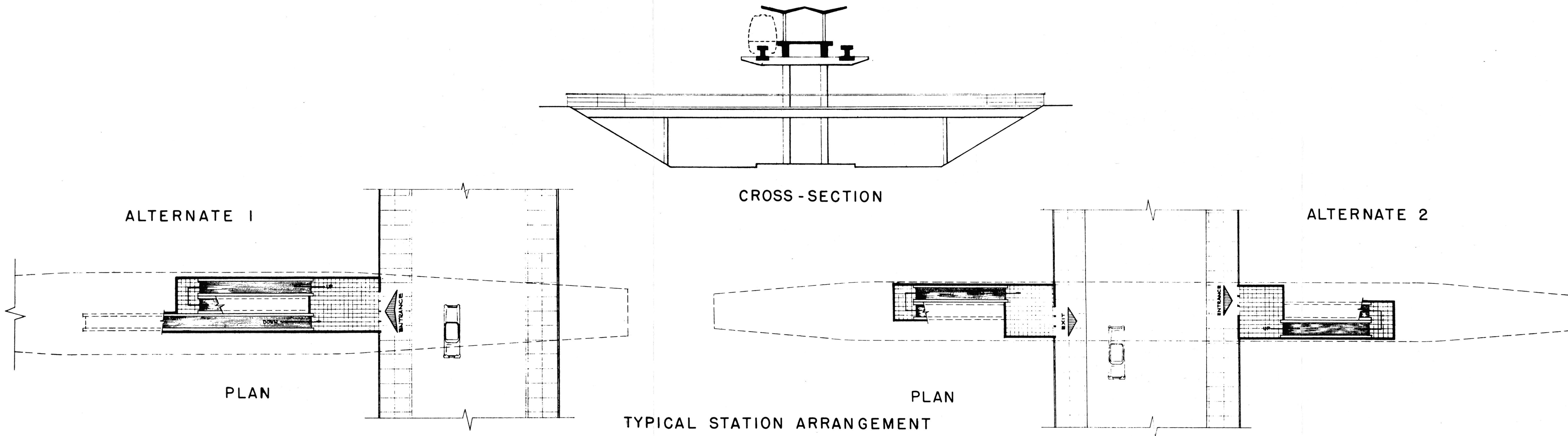
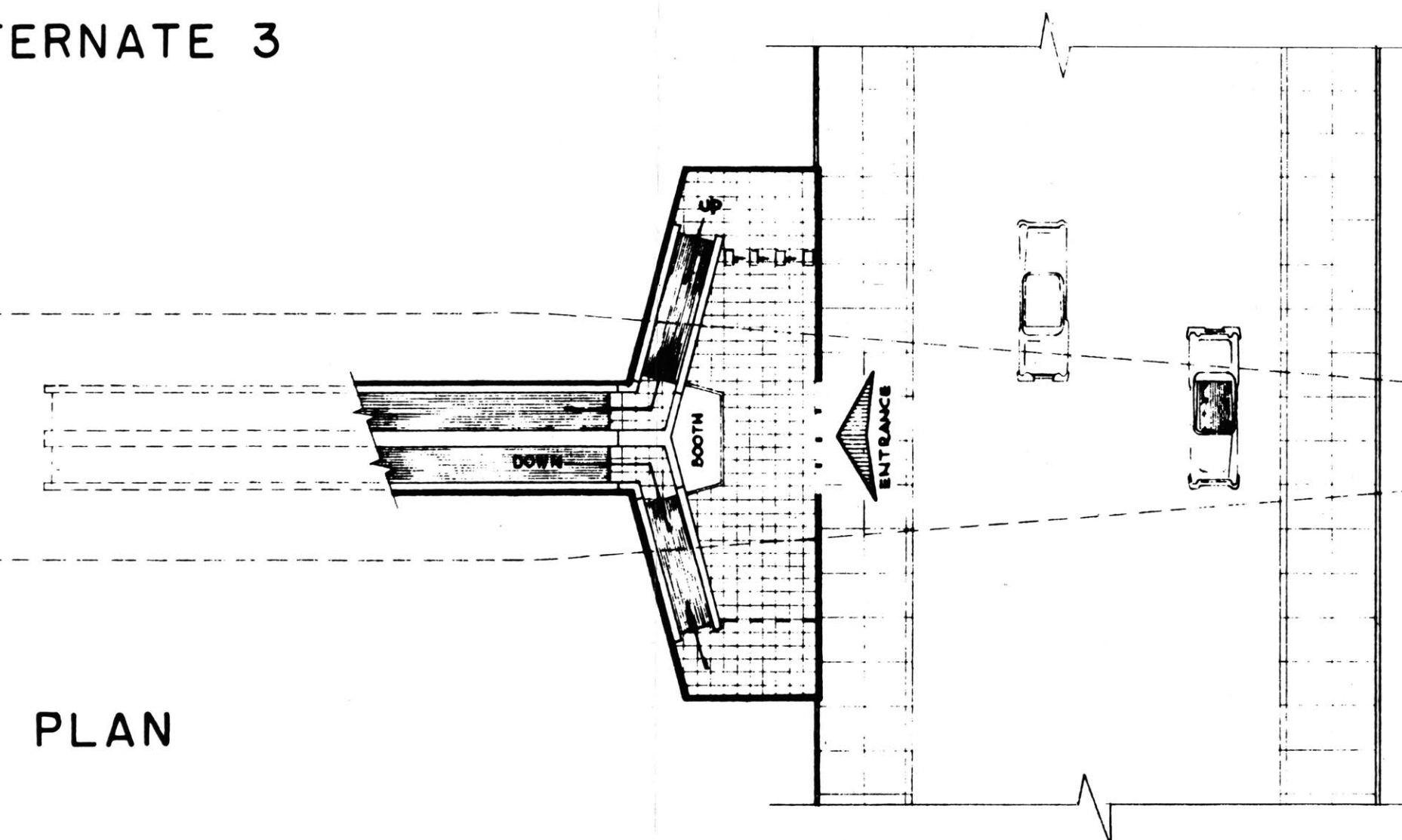
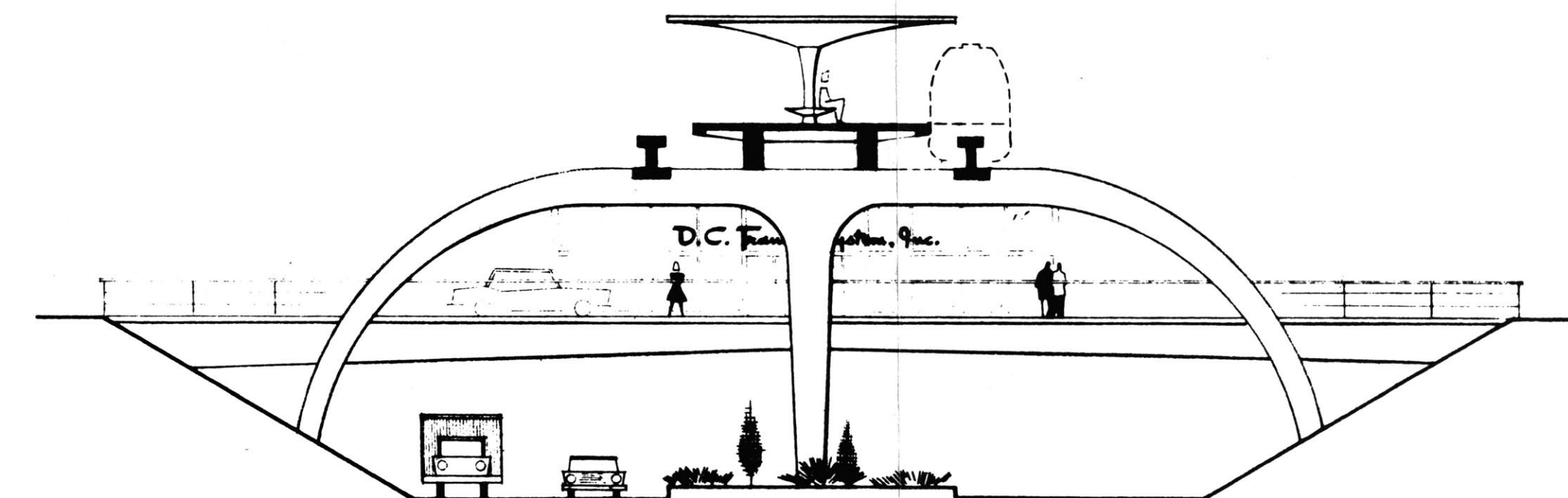


FIG.8

ALTERNATE 3



PLAN



CROSS - SECTION

TYPICAL STATION ARRANGEMENT

FIG. 9

APPENDIX B

The following is a selection of pertinent pages from the actual presentation by S.H.Bingham of his transit car system.

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The Bingham System
A New Concept of High-Speed
"Fail-Safe" Mass Transportation

Designed, Engineered and Patented
By
Colonel S.H. Bingham, (Ret.)
Consulting Engineer

April 15, 1966

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The new and meritorious features incorporated in the design and engineering configurations of the Bingham System include the following capabilities, a substantial number of which are not universally common to other media of mass transportation:

- a. It is a truly high-speed system, due in part to more expeditious switching procedures and to less need for speed restriction on curves. It is, however, fully adaptable to any lower range of speed requirements.
- b. It is not a monorail system. Actually, it is a dual-rail, multi-purpose system employing pneumatic tires in combination with conventional steel wheels, Drawing No. 1311-G, or conventional steel wheels on steel rails.
- c. The structure necessary for its operation, which can be either prestressed concrete or steel, is dimensionally smaller than those required by other proposed systems.
- d. Due to its smaller overhead structure less shadow is cast, Drawing No. 1310-B.
- e. Its structural dimensions underground are less than those of other systems, as shown in Drawing No. 1310-B.
- f. The riding surface of the beam of the Bingham System is adjustable as shown in Drawing No. 1311-G, permitting superelevation to be obtained on curves without the need for precise beam twisting during fabrication. Later irregularities or settlements of the structure can be corrected through adjustment without involving costly structural realignments.
- g. Conventional dual-rail switching is employed, Drawing No. 1350, and reverse running is secured. The necessary time-consuming and cumbersome openings of track sections and dangerous gaps in structure required by the monorail principle, either suspended or overrunning, are eliminated in the Bingham System.

- h. Positive protection is assured in the event of any tire blow out or deflation on either the supporting or guiding wheels, Drawing No. 1311-G.
- i. Higher rates of braking than those normally achieved at present are made possible through the use of a novel patented arrangement whereby maximum multiple braking forces can be applied, especially for trains operated at high speeds, which provide for the rapid stopping of trains with safety, in less than one-third the distance now required by trains operated at high speeds.
- j. Cars have lower center of gravity and superior stability under normal or stress conditions, Drawing No. 1351. A normal car floor arrangement is provided, no wheels project into the interior of the car.
- k. Normal dual-rail operation of cars, at ground level, in inspection sheds and lay-up yards is possible. No obstructive beams are necessary, due to ability to utilize steel wheels either during switching, or with steel wheel on steel rail operations. Existing monorail systems, either suspended or overrunning, cannot function in this manner.
- l. Vitally important features incorporated in signal track circuitry of the Bingham System, for which patents have been granted, prevent the possibility of trains colliding into the rear end of a stalled train. Systems employing the monorail principle with pneumatic tires, lack this essential safety feature.
- m. The cars of the Bingham System are fully compatible with automatic operation should such a procedure be considered.
- n. The unique design and engineering features of the Bingham System make possible the operation of a high or medium speed, multi-purpose, "fail-safe" mass transportation system.

- d. Loads resulting from longitudinal forces developed by the acceleration, running and braking of the trains.
- e. Thermal forces - which have been guarded against by the appropriate placement of expansion joints.

2.3 Basis for Design

Details for the loading analysis upon which the structural design has been based are given below:

Basic Car Data

Length	60'
Height - car plus beam	15'-2"
Width	10'
Weight, loaded	75,000 lbs.
Distance between trucks	42'
Wheel base	4.8'

Structure Data

Clearance above ground	14'
Height of center of wind pressure above ground footing	24'

General Design Factors

Impact coefficient	25%
Wind load	15 lbs. per sq. ft.
Lateral gravity component	10%
Lateral earthquake forces	10%
Maximum deflection allowed	1/800 of span
Maximum torsional deflection allowed	.03 degree/ft.
Weight of supporting and guiding rails	200 lbs./ft.

2.4 Supporting Columns

Several configurations have been developed for use in the fabrication of the supporting columns. Their dimensions at the foundation level require substantially less ground area than conventional overhead structures. It was considered that with towers 14' in height, where placed on tangent alignment, a spacing of 70' would be aesthetically acceptable and would also provide structural economies. Piling would be used where soil pressures are not adequate to sustain loads.

2.5 Beams

The beam would be fabricated from prestressed concrete, steel or a combination of both. A design objective, which was realized, was to develop a beam section having minimum dimensions and weights compatible with the loading stresses to which it would be subjected. The beam cross-section therefore will achieve the maximum moment of inertia in both the vertical and horizontal direction for minimum weight provision.

The method employed of associating the beam with supporting columns, Drawing No. 1336, makes possible a structure with a lower overall height, including the car height. As mentioned earlier,

this particular feature of the proposed design develops a loading moment at the base of the supporting column, lower than that which other systems have been able to attain.

2.6 Adjustable Rails

The measure of car riding comfort and its requirements for maintenance depend upon the lateral and vertical alignment of the surface upon which its supporting wheels operate. If no adjustment of this surface is provided, the ultimate end result will be rough riding and high maintenance. With systems employing guide wheels, the rails upon which these wheels run must also be provided with means for lateral adjustment.

The Bingham System provides for adjustment of the rails, both supporting and guiding, and these adjustable features have been integrated with the beam configuration in a composite design. Provision has been made in the supporting and guiding rails to allow for variable adjustments within the range of plus or minus 2".

It is not realistic to expect that adjustment of the running surfaces would not be necessary. During construction variations in the alignment of the structure sections, either vertical or lateral or both, are reasonable assumptions.

adjustment which has been developed for the Bingham System. This is another important feature of this new design as it makes possible the fabrication of the beam at lower costs and with production time reduced.

2.7 Current Carrying Contact Rails

The guiding rails have been designed to serve a dual purpose: to guide the car and to carry electrical energy for the electrical traction motors and the car auxiliary equipment.

2.8 Shadow Cast by Structure

A rapid transit system operating on an overhead structure would cast three shadows:

1. The beam,
2. The supporting column,
3. The passing train.

The shadow cast by the beam would be continuous, that cast by the supporting columns intermittent, governed by the spacing and dimensions of the columns, and the shadow cast by the passing train would be periodic.

The surface area brought into shadow by the beam is a matter for critical consideration. Due to its arrangements and smaller dimensions, the extent of the shadow cast by the structure

the Bingham System is substantially less than that of other systems, a feature which offers both aesthetic and economic advantages. A comparison of the areas brought into shadow is shown in Drawing No. 1310-B.

3.7.1 Braking

Train deceleration will be accomplished by dynamic braking supplemented by a modern system of disc brakes.

For normal service conditions, automatic dynamic braking would be provided with selective rates up to 3 mphps. When dynamic braking begins to fade, its braking effort would be supplemented by the disc brakes to bring the train to a stop and hold it in a stationary position.

Emergency braking would be accomplished at higher rates through the immediate operation of the dynamic and disc braking systems acting in unison. The dynamic braking control would function in response to the position of the single handle controlling both the dynamic and the disc brakes.

3.7.2 Braking of High-Speed Steel Wheeled Trains

In the operation of vehicles or trains equipped with steel wheels at speeds of 150-225 miles per hour or higher, special provision must be made for the safe braking of the train down to lower speeds and, ultimately, to a standstill. Due to the low level of adhesion between the steel wheels and the rails, which grows lower as train speeds increase, the initial rate of retardation applied through the steel wheels either mechanically or

electro-dynamically must be at a comparatively low level to guard against wheel locking.

The Bingham High-Speed System, a development of the Bingham System, includes a novel arrangement, for which a patent has been granted, whereby additional braking effort can be applied to vehicles or trains, especially when operated at high speeds, through the use of the guiding or stabilizing wheels, which can be effected independently of or in combination with the application of the braking effort to the main or running wheels of the vehicle. Thus, the maximum braking forces for the train can be applied. This adequate multiple braking effort provides for the rapid stopping of trains with safety, within one-third the distance now required by trains operated at high speeds.

3. 7. 3 Car Speed - Acceleration and Maximum Speed Relationships

The questions of acceleration and the maximum speed of which a transit vehicle or train of the so-called monorail type is capable have been confounded by claims, the majority of which, are imaginative and unrealistic.

A system which is intended to function as a medium of mass transportation with stations spaced one mile apart, or even less, has fundamentally different conditions of acceleration and

maximum speed capabilities to satisfy, than one with more widely spaced stations. Both systems, however, have one common objective, namely: the conservation of running time between station stops.

With closely spaced stations a high rate of acceleration and a motor design which permits the controlled acceleration to be carried to higher speed levels, is a more important consideration than high maximum or balancing speeds. The maximum or balancing speed of the equipment may not be attained between closely spaced stations, or if it is attained, the interval of high speed running will be uneconomically short.

Where stations are widely separated, on the other hand, a high rate of acceleration is of less importance to time saving between stations than the ability of the equipment to develop high speed.

It is possible to provide electrical propulsion equipment capable of both high rates of acceleration and high values of maximum speed. This would be an uneconomical procedure as the higher costs for increased power consumption, due to increased motor ratings, would not be balanced by a commensurate saving in running time or an interval of coasting during which no power would be used.

To restate the well known conditions, i. e., the speed of a car of given weight and wheel diameter propelled by electric motors

of given horsepower at a given current and voltage, with due evaluation of train resistance and track profile and alignment, depends upon the gear ratio selected.

3.7.4 Considerations Affecting Power Consumption

Energy in the form of kilowatt hours per car mile is expended to propel a rapid transit train and the specific variants of the above conditions selected will determine the resulting performance of the train in acceleration and maximum speed as well as the kilowatt hours per car mile expended. A high rate of acceleration requires a heavy starting current, and if this is to be followed by a high maximum speed demanding high rates of current consumption, the kilowatt hours per car mile will increase accordingly.

Economies may be effected through the selection of propulsion equipment capable of high rates of acceleration and moderate maximum speeds for cars intended for a service involving short distances between stations. For service involving substantial distances between stations, moderate rates of acceleration and high maximum speed capabilities would be appropriate.

An additional factor to be considered is that the consumption of energy in kilowatt hours per car mile is augmented by increases

3.7.8 Rates of Acceleration

Adjustable rates of acceleration up to 3 mphps or even higher can be provided. Operating experience, however, has established that possible minor variations in the rate of acceleration at the lower rates of 2.25 to 2.5 mphps are tolerable to the passengers and provide safety and comfort for the riding public.

Propulsion equipments, capable of providing maximum speeds of 65 to 85 miles per hour for mass rapid transit service, are obtainable as components of the newly designed cars of the Bingham System.

3.8 Major Truck Components

This section provides expanded information pertaining to the novel truck designed for the Bingham System. The numbers cited in this text relate to corresponding numbers shown on the Drawing No. 1417.

The truck assembly herein described consists of four distinctive features:

- a. One non-pivoting bolster (1).
- b. Two pivoting side frames (2) which are free to swivel with respect to the bolster.
- c. A suspension system of advanced design (Drawing No. 1409).

engineering of the Bingham System, are not attainable by top of beam overrunning monorail systems, at least as they are now constituted.

3.11.3 Supporting Tires as Stabilizing Media

Certain of the top of beam overrunning systems, currently being offered, follow the monorail principle of operation. Due to this fact, the vertical reactions of the supporting wheels cannot be used to stabilize the car. This condition necessitates the provision of extra sets of guiding wheels and additional trackage in the form of double sets of guiding rails, two on each side of the beam, therefore, two running surfaces on each side of the beam.

For car guidance alone only one set of guiding wheels and two guiding rails, one rail on each side of the beam, are necessary. With the monorail principle the guiding wheels, lacking any stabilization effort from the supporting wheels, must also function to resist the rolling moment imposed by lateral forces acting upon the car. It follows, therefore, that regardless of the additional guiding wheels provided, the loads imposed upon the guiding tires of such monorail system, under certain conditions, may be of great magnitude. This is an important and frequently overlooked consideration.

3.11.4 Loads on Guiding Tires

By comparison, the dual running rails of the Bingham System provide for the absorption by the tires of the vertical reaction of the supporting wheels.

Hence, the sole function of the guiding wheels is to perform that duty, they are not involved in the stabilizing process. Only one set of guiding wheels, therefore, is necessary as the tires are loaded only by the sum of the lateral forces applied to the car. These forces are aerodynamic and dynamic (centrifugal inertia) by nature. The advantages secured by the Bingham System through this important design feature will be realized in lower maintenance costs and superior operation.

3.12 Switching

This critically important operation is performed by the Bingham System in the conventional manner, employing standard railroad switching components. The steel wheels are mounted beside the rubber tired supporting wheels and, upon an approach to a turnout or crossover, a train running on pneumatic tires makes a smooth transition to steel wheel on steel rail and performs the switching operation, in the same manner as a conventional dual rail rapid transit or railroad train.

Compare the ease and simplicity of switching provided by the Bingham System with the methods employed in existing monorail systems, whether overrunning or suspended. It is necessary, with these systems, to open a length of the beam in order to perform the switching operation at a point of turnout or crossover. The result is a gap in the beamway which creates a dangerous condition. This gap, in addition to eliminating the possibility of reverse running, could inadvertently result in a tragic happening.

The following limiting conditions must therefore be faced by systems required, by their design, to open a length of the beam in order to perform the switching operation:

- a. The slow movement of a ponderous beam section.
- b. The existence of a hazardous gap.
- c. The inability to provide for reverse running through switch points.
- d. The necessity to provide a more costly installation with increased operating and maintenance expenses.
- e. The inability to earn unqualified "fail-safe" approval.

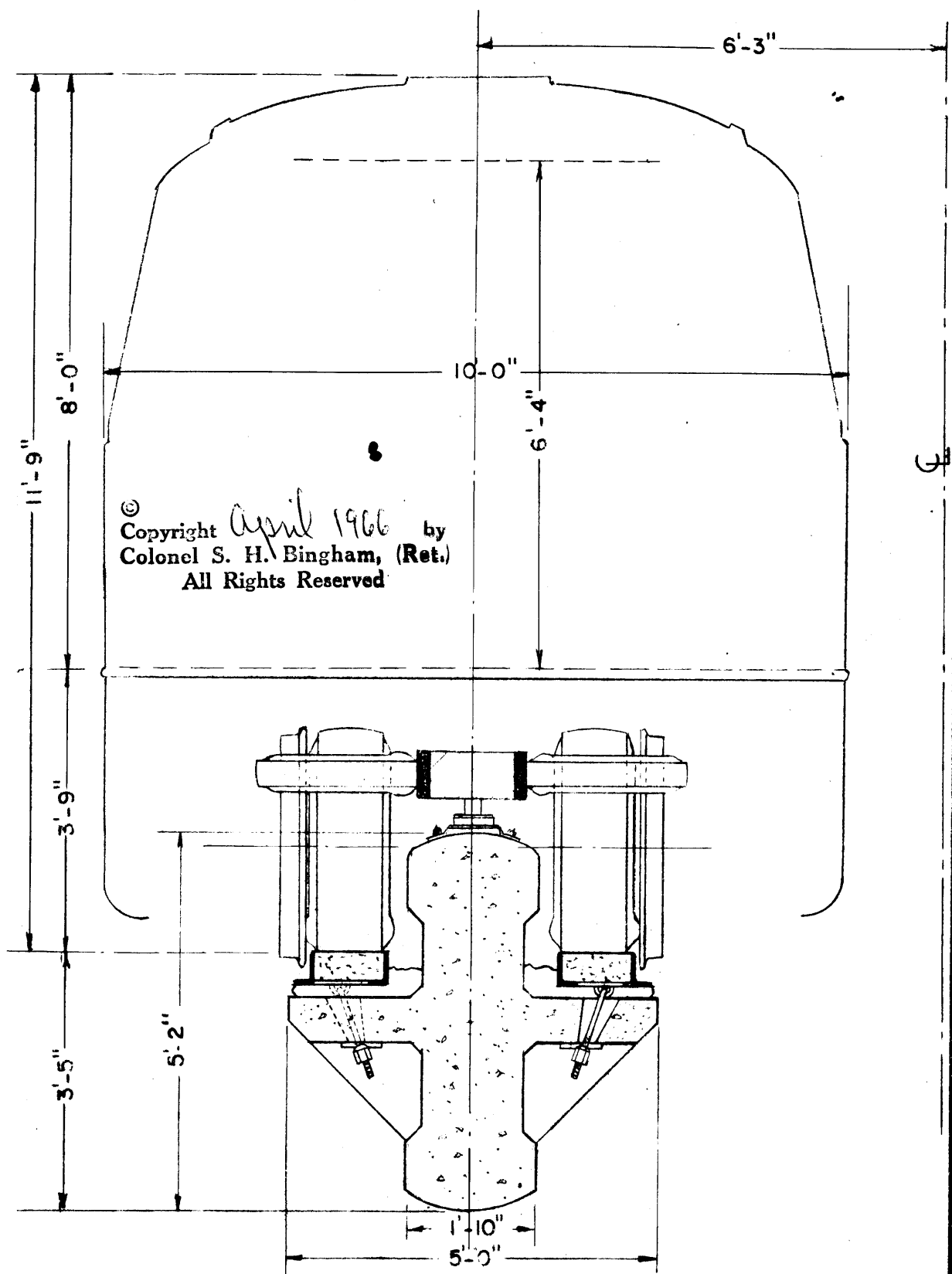
In addition to potential danger, the movement of the ponderous beam member is, at its best, time-consuming and not in harmony with the time-saving tempo of modern rapid transit operation.

It is important, therefore, to restate that the Bingham System permits standard switching procedures and reverse running by the cars through conventional switch points. The importance of this operation cannot be overemphasized. Primarily it provides assured safety. A secondary but important consideration is that it satisfies modern high-speed operating demands.

3.12.1 Operation in Storage Yards and Maintenance Shops

The guidance of the car, when operating on pneumatic tires through switch points and special work, is the function of the steel wheels. This ability to function in a conventional manner is highly important for operation in storage yards and maintenance shops, where the obstructions caused by beam structures would be restrictive and objectionable.

The Bingham System permits the switching and operation of cars, on the main line, in lay-up yards and in maintenance shops, to follow the procedures common to conventional dual-rail subway or railroad operations. The need for prohibitively obstructive beam sections, required by other systems, which would hamper car train movements in shops and yards and over ladder tracks, does not exist with the Bingham System.

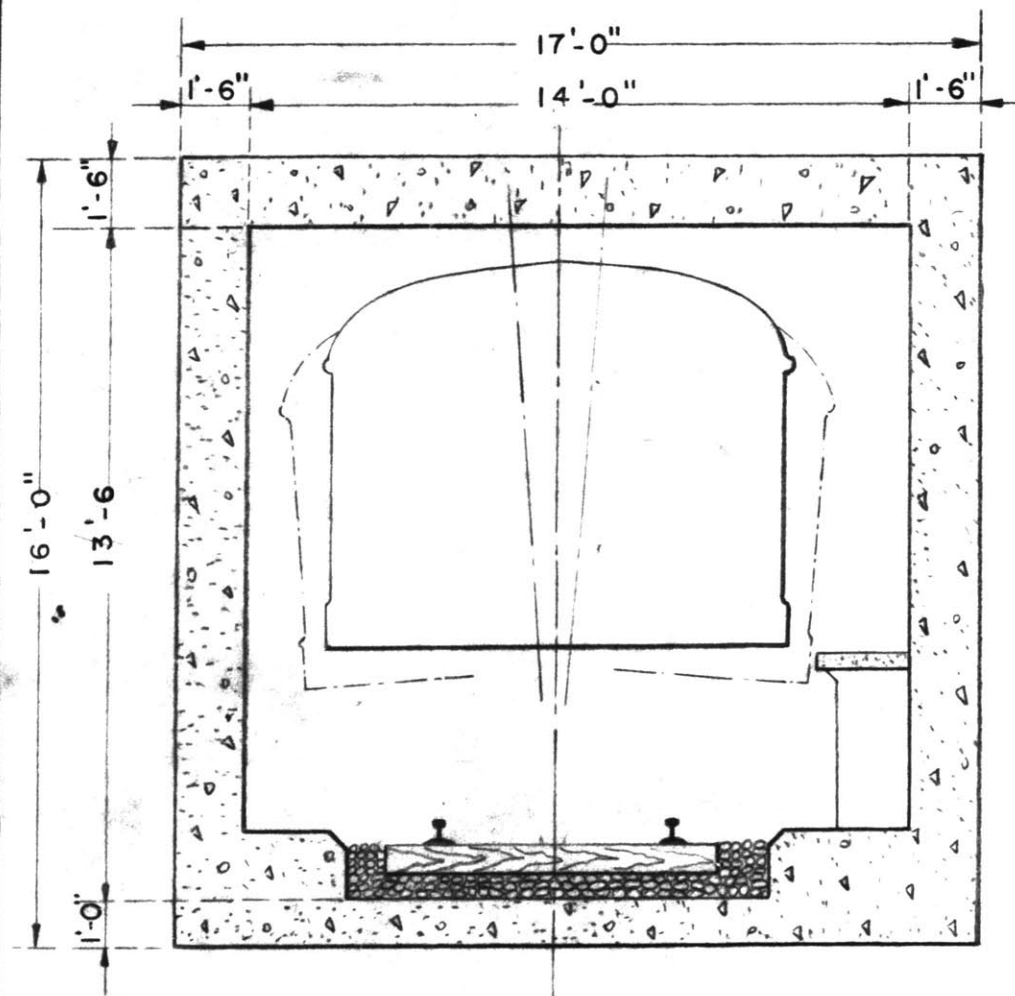


CAR ON TANGENT OVERHEAD STRUCTURE

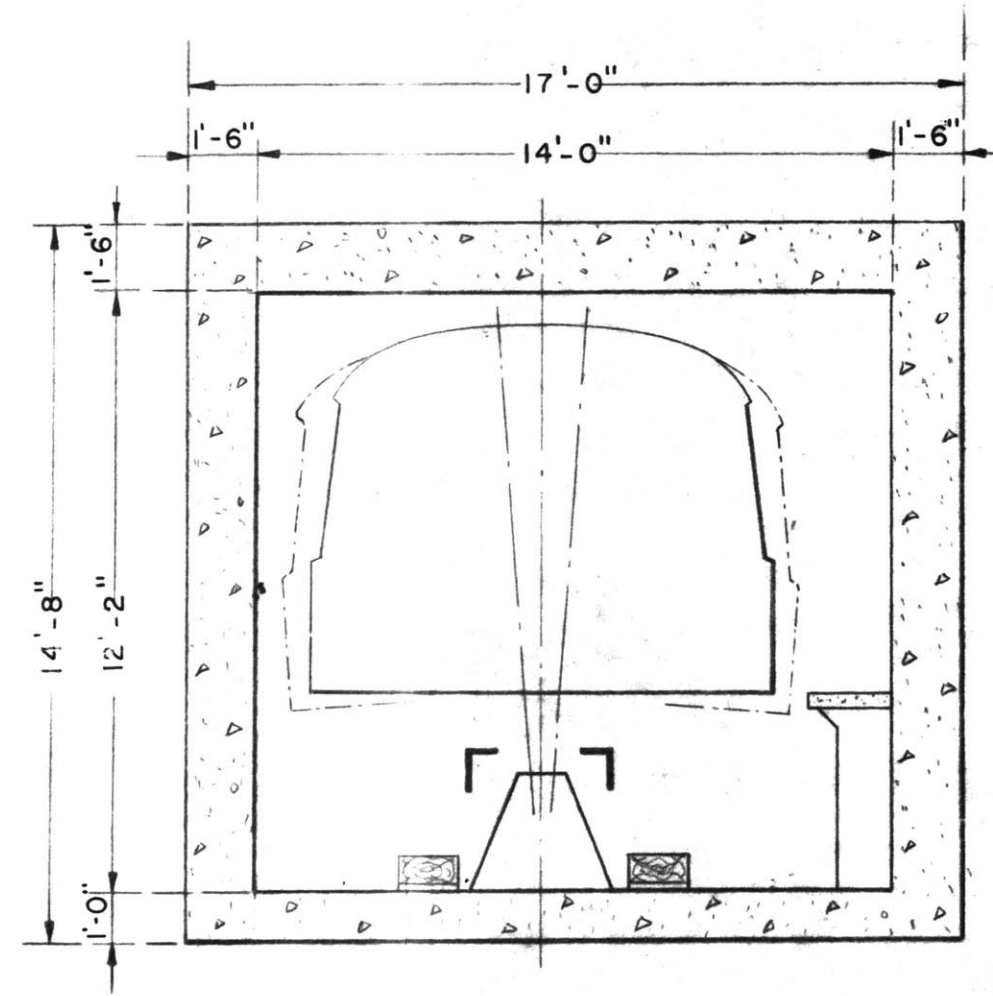
Scale $\frac{1}{2}" = 1'$

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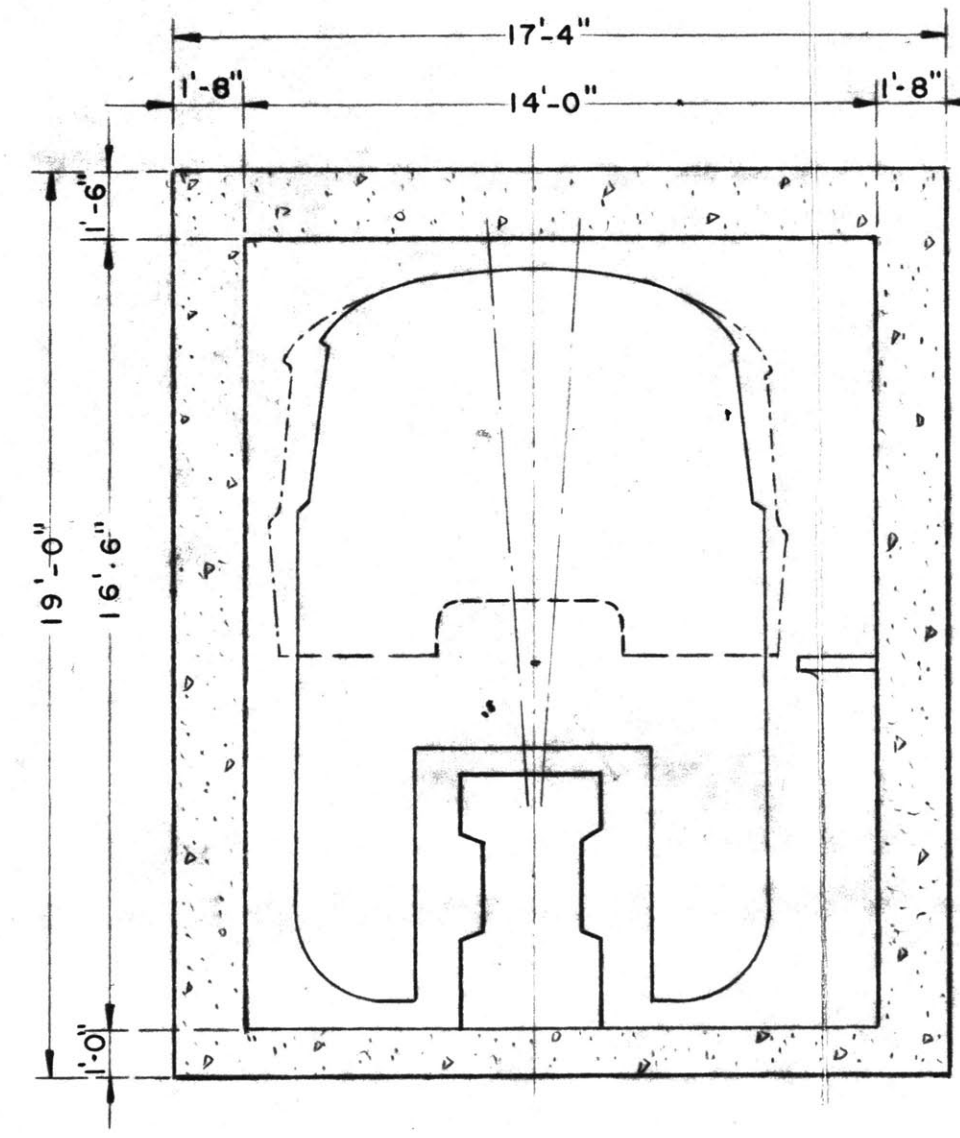
DWG. No. 1311-G



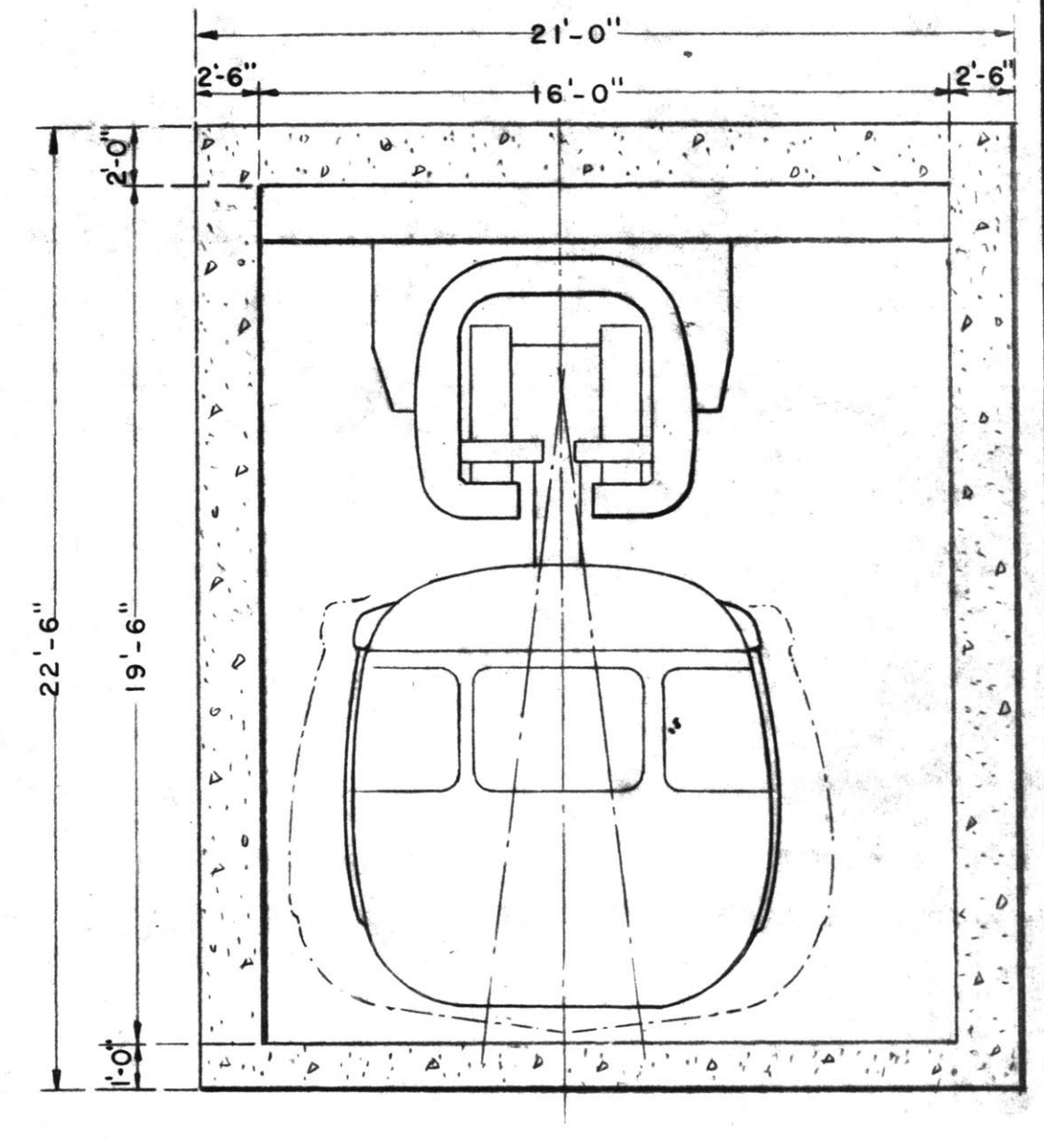
A



B



C



D

	EXCAVATION* Cu. ft / ft	%	CONCRETE VOLUME Cu. ft / ft	%
A	374	106	89	113
B	352	100	79	100
C	434	123	98.3	124
D	599	170	160.5	203

TUNNEL DIMENSIONAL COMPARISONS

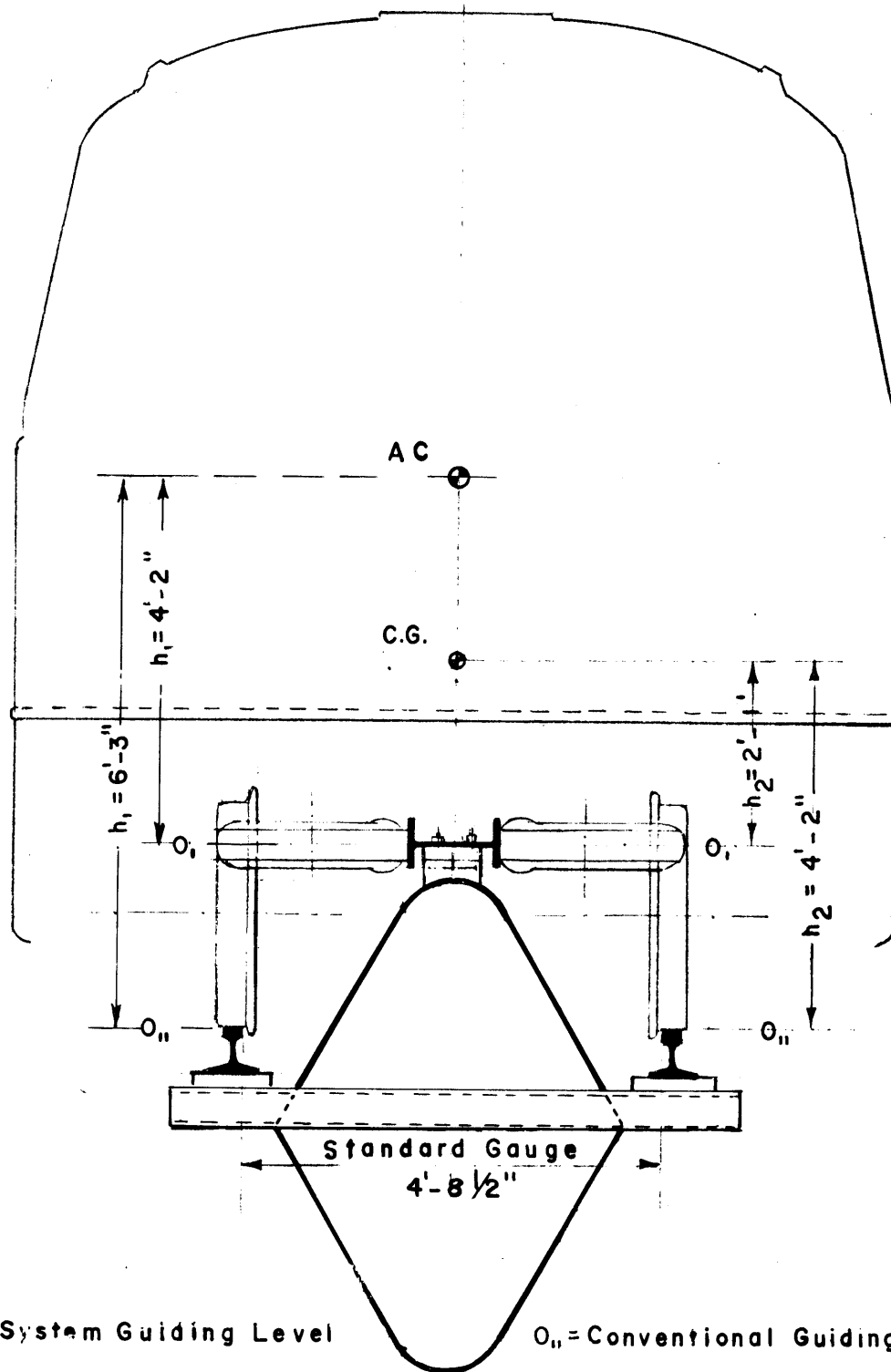
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* Top of Tunnel is assumed to be 6' below street in all cases

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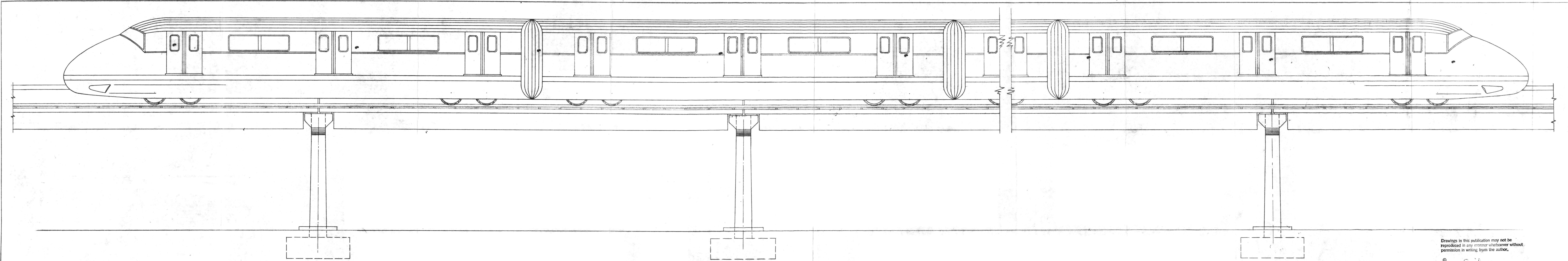
O_1 = Bingham System Guiding Level

O_{11} = Conventional Guiding Level

VIEW OF CAR WITH STEEL SUPPORTING WHEELS
AND RUBBER GUIDING WHEELS FOR HIGH SPEED OPERATION

Scale: $\frac{1}{2}" = 1'$

DWG No. 1339



TYPICAL SIDE ELEVATION OF TRAIN ON OVERHEAD STRUCTURE

SCALE: 1/4" = 1'-0"

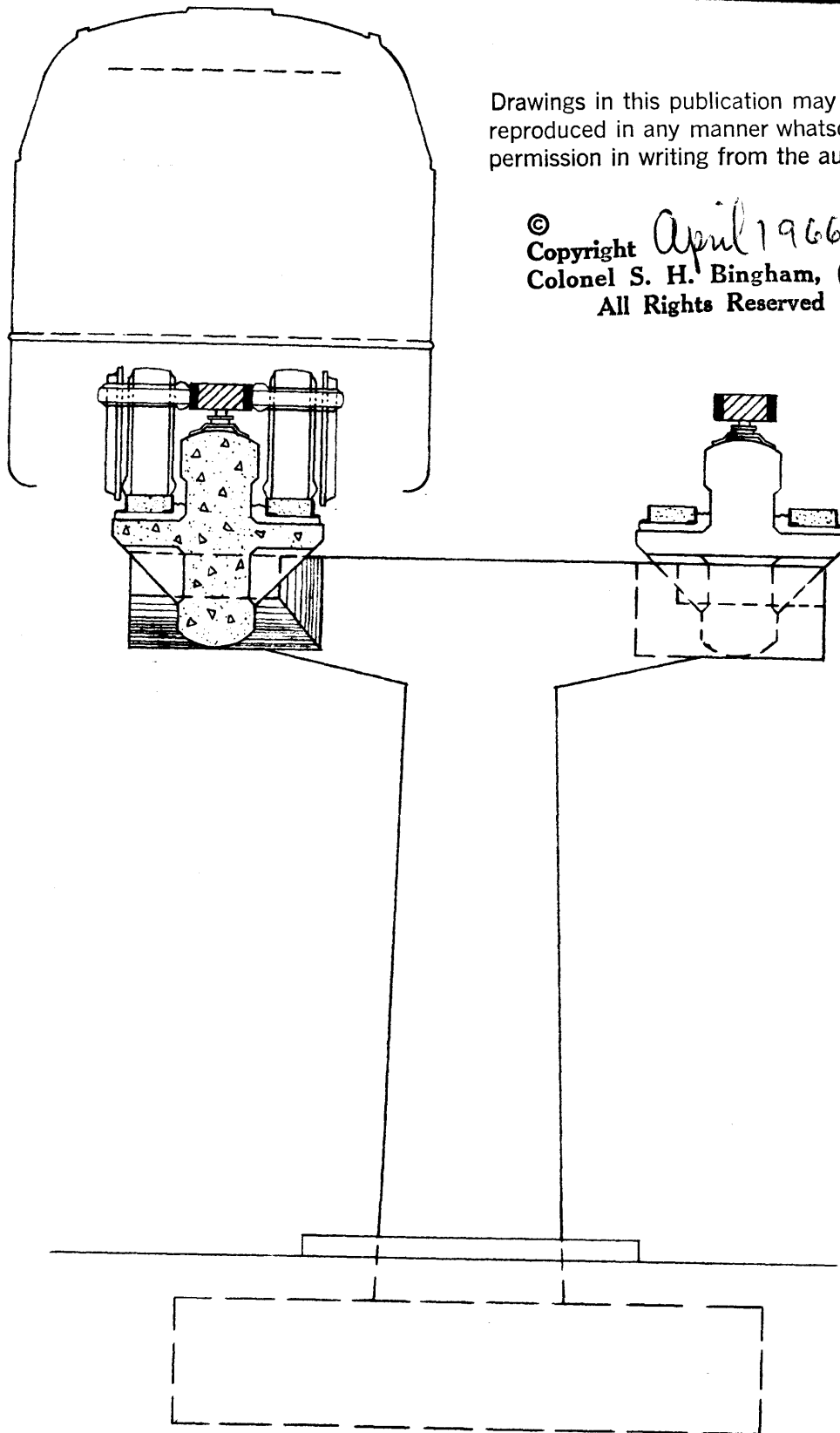
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OCT. 10, 1964
DWG. No. 1343-A

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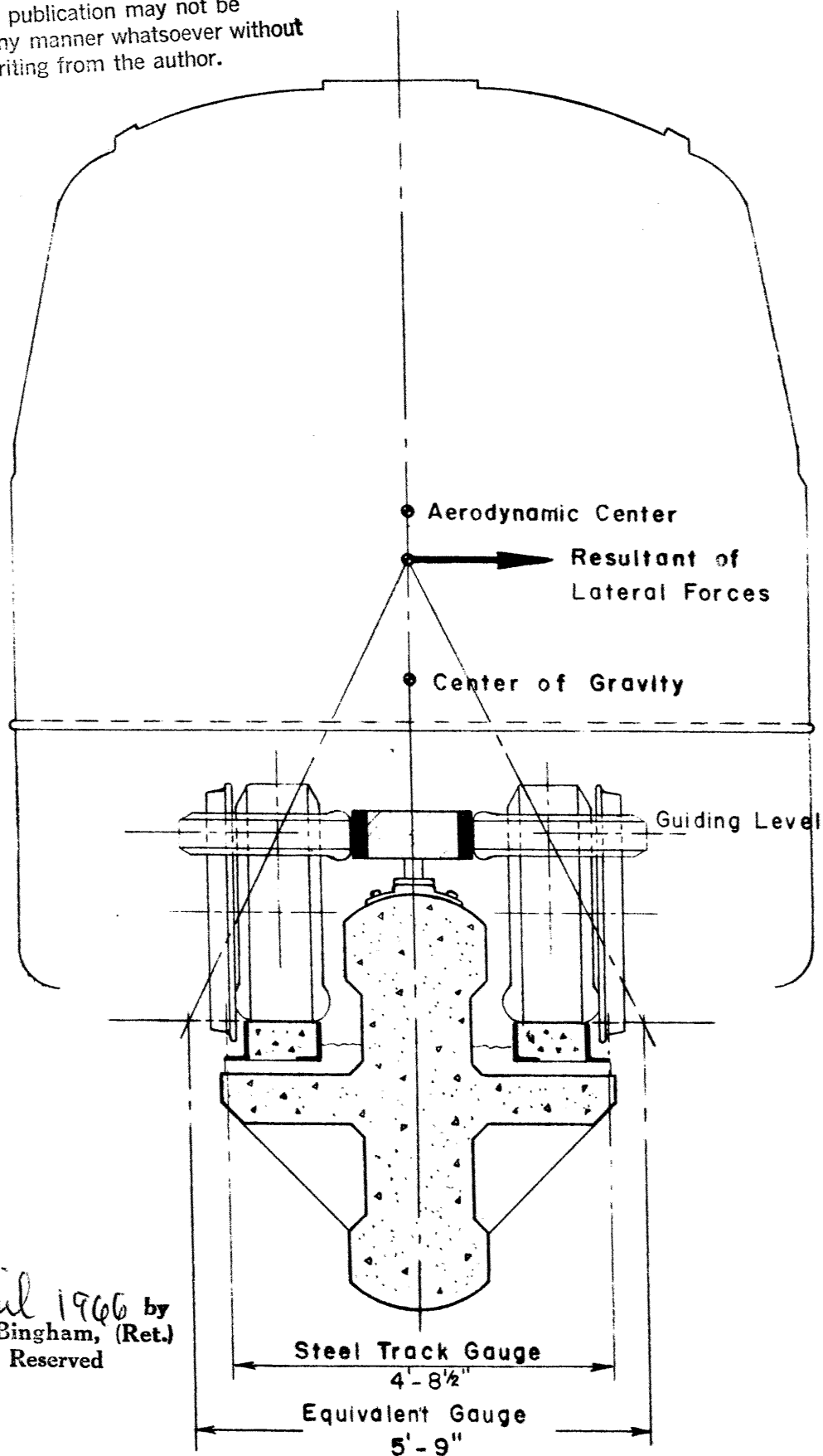


TYPICAL FRONT ELEVATION ON OVERHEAD STRUCTURE

SCALE: $\frac{1}{4}" = 1'-0"$

DWG. No. 1343-B

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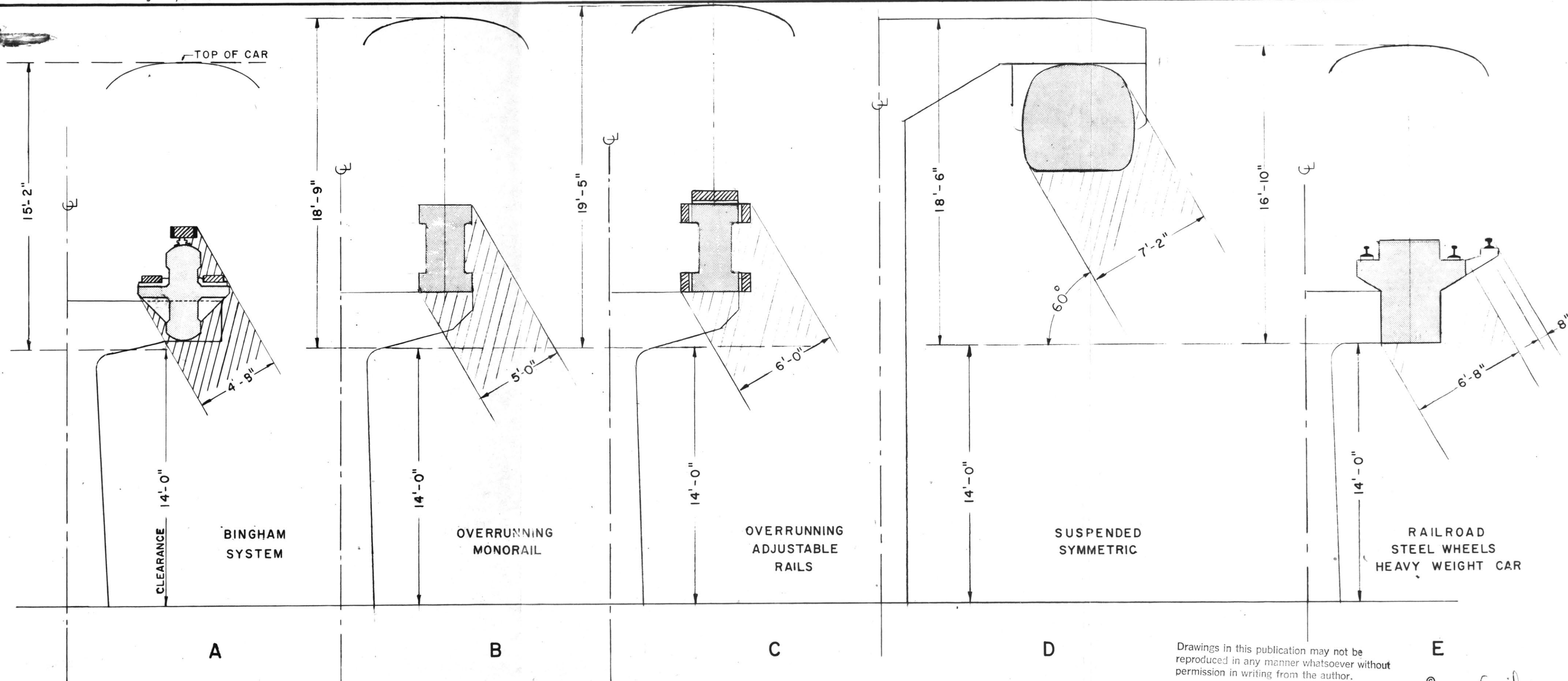


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EFFECT OF GUIDING LEVEL ON STABILITY

SCALE 1/2" = 1'-0"

DWG. No. 1351



COMPARISON OF STRUCTURES AND SHADOWS CAST
AT 60° ANGLE OF SIGHT
SCALE: 1/4" = 1'

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DWG. No. 1310-B

APPENDIX C

Project Metran and Perception

Last year M.I.T. students from various departments participated in a course for study of an integrated, evolutionary, transportation system for urban areas. The findings of this study has been published under the title Project Metran. Their study has presented some important criteria for evaluation of a transportation system. The study has been careful to articulate its attitude concerning visual continuity with respect to high speed transit systems.

"For example, the visual experience of transportation is important to the pleasure of the trip and the user's sense of location and orientation during the trip. For these reasons it is felt that the user should be allowed a view of the city as he travels.... As an object passes the field of view its movement is recorded as a rate of change of its angular position. High angular velocities cause blurring of the object viewed and hence make orientation a more difficult problem. This angular velocity can be expressed as follows:

$$w = \frac{a}{a^2 + b^2} SC$$

where w = angular velocity (degrees/second)
 a = the distance to the object perpendicular
 to the line of travel
 b = the distance to the object parallel to
 the line of travel.
 S = the speed
 C = an adjustment factor for the various
 units used.

This equation is expressed graphically in Illustration IV. The lines represent locus of point having constant angular velocity relative to the observer, and hence they define zones of increasing angular velocity as you approach the object.

Four policies have been proposed to achieve these objectives:

1. Design control of (vehicles), structures and network configurations sufficient to assure that aesthetic qualities are a criterion for transportation design.
2. Provision of funds to permit proper attention to protection from visual disruptions. Expediency and dollar-value efficiency must give way.
3. The system should serve a positive visual function through such means as delineation of boundaries between different (and especially incompatible) areas, exposing its users to the environment through which they are travelling, and through relation to strong visual elements such as major topographical features, landmarks, and important areas of activity.
4. The system should symbolize a direct form of communication, linking different areas in the region psychologically as well as functionally."

Metran has specified as a part of its transportation system a High Speed Ground Transit loop abbreviated by HSGD. The system operates at 120 to 350 mph. Several valid reasons are given for raising the system above ground level.

1. It would be less expensive to attain a level alignment of track on a structure than ballasting at grade.
2. Personnel safety ("third rail") and protection from vandals is far superior.

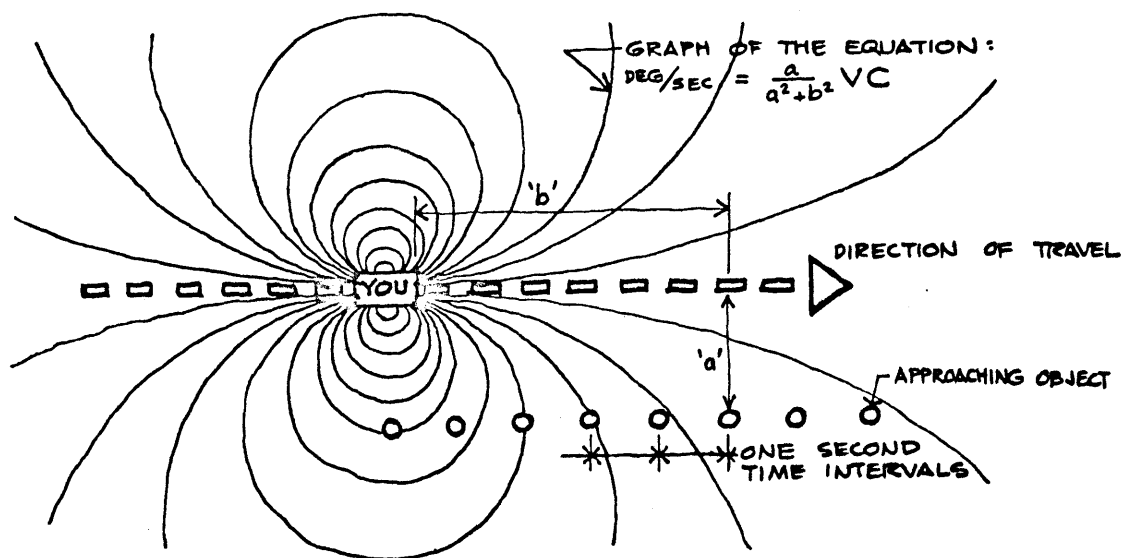


Illustration IV. The Visual Experience of the Traveller

3. By lifting these high speed vehicles above the ground and average tree and building height, one would reduce or prevent the blurring of objects in the near field of vision.
4. It also seems advisable to separate vehicles traveling at 60 mph from vehicles traveling next to 300 mph. The rapid passing of vehicles is amusing in a Keystone Cops movie, but would be less entertaining in actual practice where the flash of HSGT vehicles would be continual, their passing might be accompanied by buffeting from their shock waves, and one's own sense of speed would be reduced. (See pp. 201-202 in Project Metran)

It is reassuring to find that the same conclusion about high speed transportation can be developed from various points of view, from Mr. Bingham and from a selection of various students of other fields.

APPENDIX D

The New Dimension of the Motion Picture

A. Film:

The best environments of the Twentieth Century have become known to the student largely through vicarious experiences. During the formative years of his education, the student must refer to books, slides, and experiences of others.

At present, the most important means of communication for architects is the picture book. It is significant that both Frank Lloyd Wright and Le Corbusier were well published and recorded. A somewhat less general means of explaining an environment is through use of the slide projector. A common example is the use of slides in an architectural history course. It was a source of amazement when a friend returned from Europe with a slide show of the Acropolis and I responded as though I had been there before.

Another source of architectural experience has been the motion picture. One of the best memories I have of Wright as a man has come from a film produced for television. The commercial cinema has also supplied its share of experiences. I have been to Brazilia with Belmondo and toured the Eiffel Tower with Alec Guinness. The most impressive movie with a building as its subject is that made by the Japanese of the

construction of the Tokyo Olympic Stadium. The medium has even been used by such educators as Professor Horatio Caminos to record the building experiences of one class for the benefit of another.

In other fields of education, movies are more popular. The Physical Science Study Committee has produced a whole series of educational films to accompany their text book. These movies are used in high schools and colleges throughout the country. The student is given the opportunity to witness important experiments with rare and expensive equipment and sometimes receive a lecture, filmed of course, from the men who originate important scientific achievements. It is amazing to me that a subject so heavily reliant on visual communication, such as architecture, has for so long left this field of education so fallow.

Few would deny that the best way to experience a building is to walk through it. The best way to evaluate a man's work is to see it and live in it. I cannot help but think that the next best way of experiencing a building is watching a movie of it. As a teaching device how grand it would be to speak with an architect about his buildings, hundreds of miles from where the film captured them.

In the past, buildings have been influenced in design by the way in which the building was studied. If the building was designed in plan and elevation it was visible in the

building. Models have come into more use in recent years and the result has been to produce more three dimensional buildings. Eero Saarinen is perhaps the most famous for this approach to design. Another approach is the use of photographs and models. It is an ideal way to demonstrate the affect sunlight will have in a building. Photographs can also lie. The camera must always remain a still point within a space. With a movie camera you can more accurately simulate movement through a space.

B. The Next Step--The Computer:

In the small book Computer Graphics in Communication by William A. Fetter, makes an attempt to delineate to some small degree the possible uses of Computer graphics in many diverse fields. One of the areas which he specifies is architecture:

"An important element in architecture is spacial relationships. While the usual drawings, renderings, and models are useful in displaying design solutions, there are a number of situations in which more articulated views or variations would be desirable. Multiple drawings, stereo views, or motion pictures having a high degree of accuracy are possible with existing capabilities. Computed drawings would be useful, not only in delineating the appearance of a structure from a number of specific viewpoints, but also in showing the relationship between new and old structures. Photographs taken with carefully controlled viewpoints could be matched to computer drawings to produce composite motion picture photography of existing and proposed structures.

It should be possible, by using existing acoustic technology, to describe mathematically in an

understandable three dimensional visual form the rebounding patterns of many different interior designs furing preliminary planning.

In studying design variations, a basic architectural form could be enlarged, reportioned, or otherwise distorted mathematically by the architect for new drawings of his design. Computer graphics would be useful in visualizing the results of other design analysis computations. For example, in the design of a multiple dwelling unit, experimentation emphasizing such parameters as traffic flow, economy, view, spaciousness, etc., might assist the architect in examining extremes and means in design approaches." (See p. 85 Fetter)

M.I.T. is in the forefront in such Computer Graphic technique. Mr. Nicholas Negroponte and Mr. Leon Groisser are now conducting a course to develop a machine that can be used by a novice to do just the things suggested by Mr. Fetter. The machine goes under the name "Kludge." It consists basically of a viewing screen, a set of foot controls and a pen-like instrument for instructing the machine. The grid which is represented on the screen describes a cube in space which is nine units on a side. Any number of unit size cubes can be placed on the screen and manipulated by instructing the machine with the indicator. The machine will project plans, sections, perspectives, and all relevant views of whatever object is designated. The future development of the machine will provide for a variable grid. If this occurs before the end of the term, it will be possible for this student to make an animated

cartoon with the computer, of some portion of the transit route.

The computer program prepared by Mr. Negroponte and explained in his Master's Thesis for M.I.T. is based upon the rudiments of visual perception. (as described in Appendix C) The computer is given an environment through which to pass. (see examples). This environment is described simply to the computer by picking an appropriate scale and filling all solids in plan with an "X" and leaving the voids blank. A path is indicated and a speed of travel is designated for the computer. The machine then makes the trip as instructed and records what parts of the surrounding environment are blurred to its vision and for how long. In the example given, the numeral 1 stands for a blur of 10 seconds, 2 for 20 seconds and so on. This program is rather easy to follow and it is hoped that phase three could include work with such a program.

[illegible]

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[illegible]

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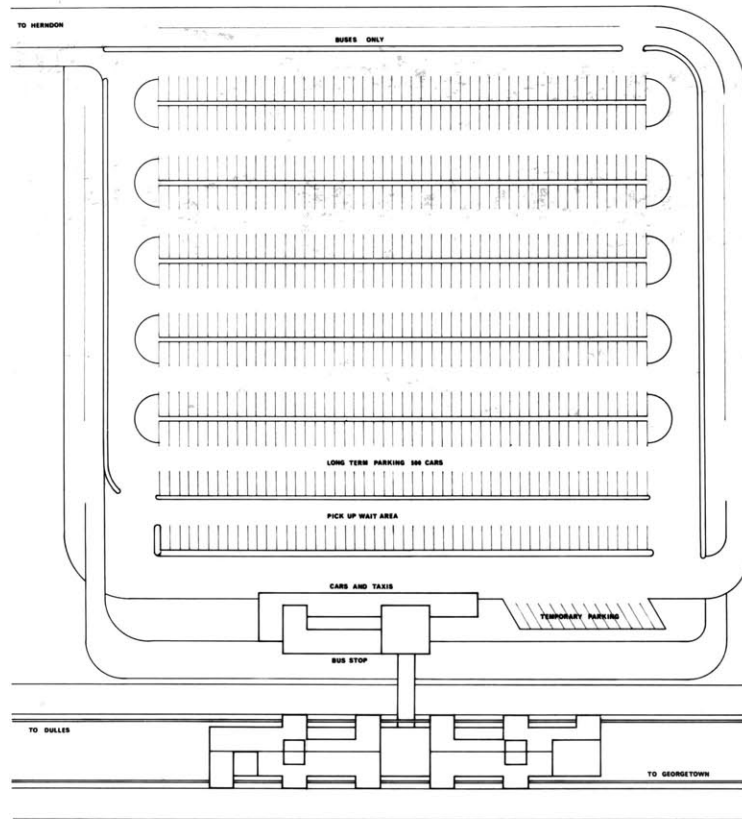
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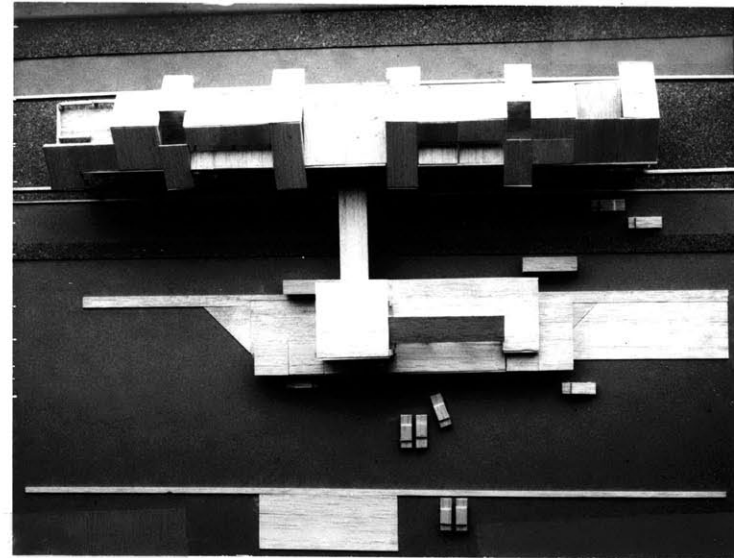
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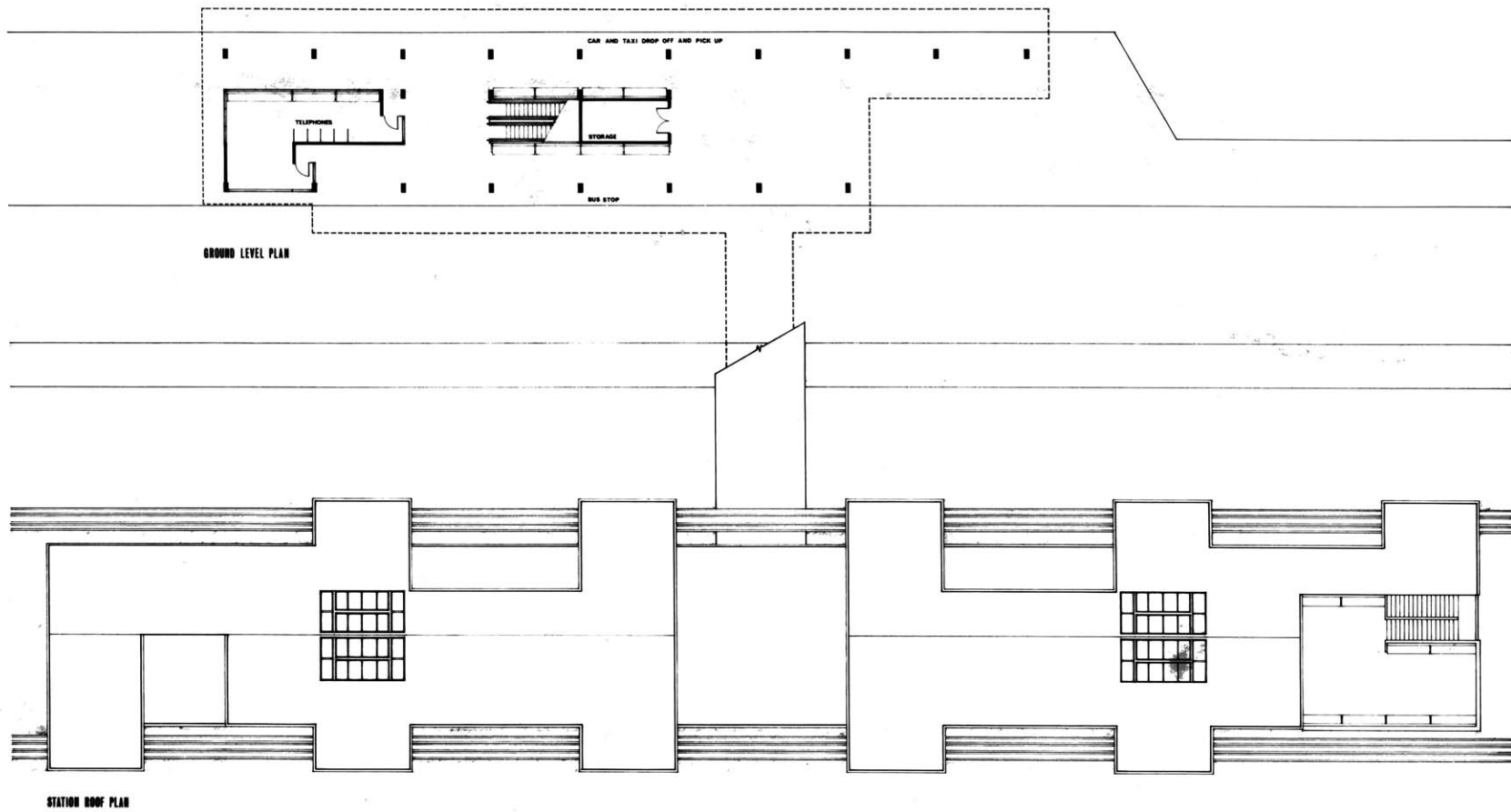


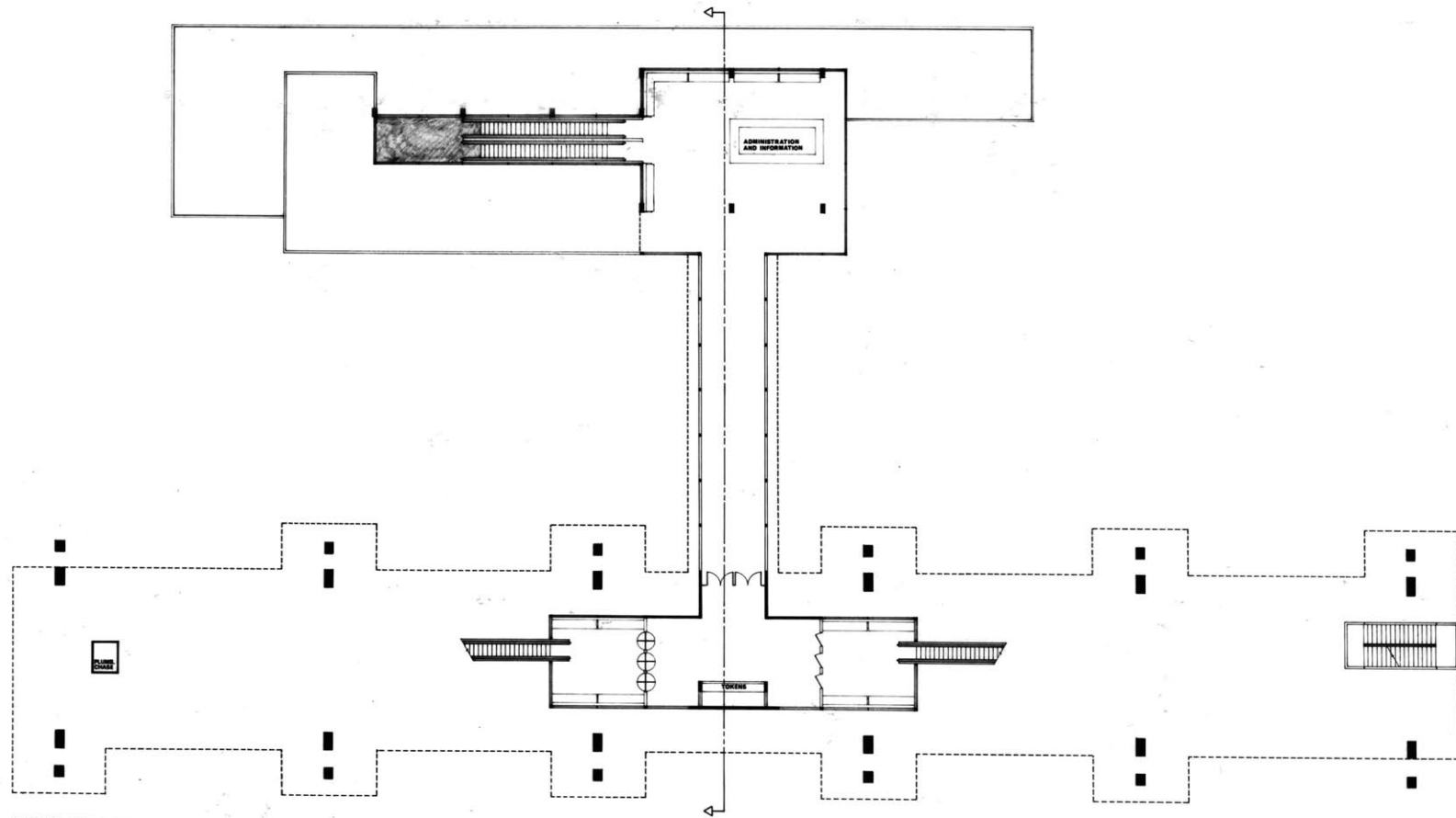
SITE PLAN
①



1 THE ARCHITECTURE OF HIGH SPEED TRANSPORTATION

RICHARD RUSH
ARCHITECTURAL THESIS
M.I.T. 1967

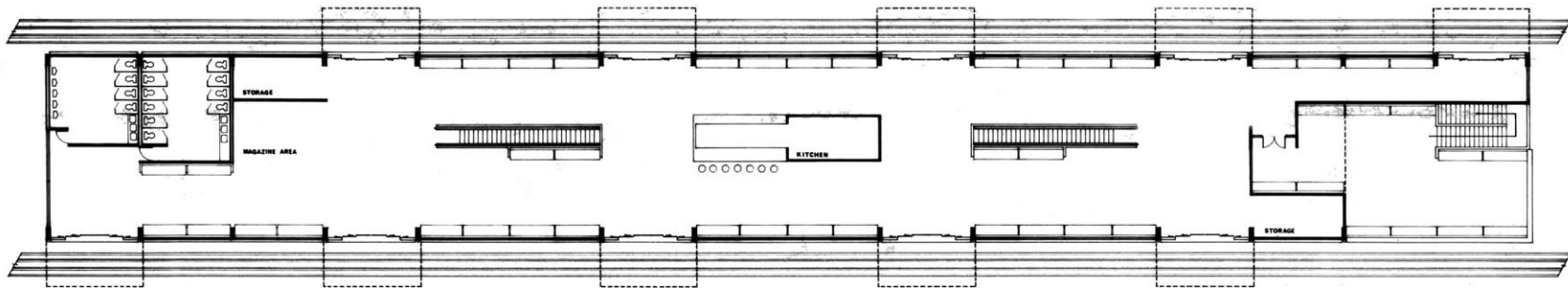




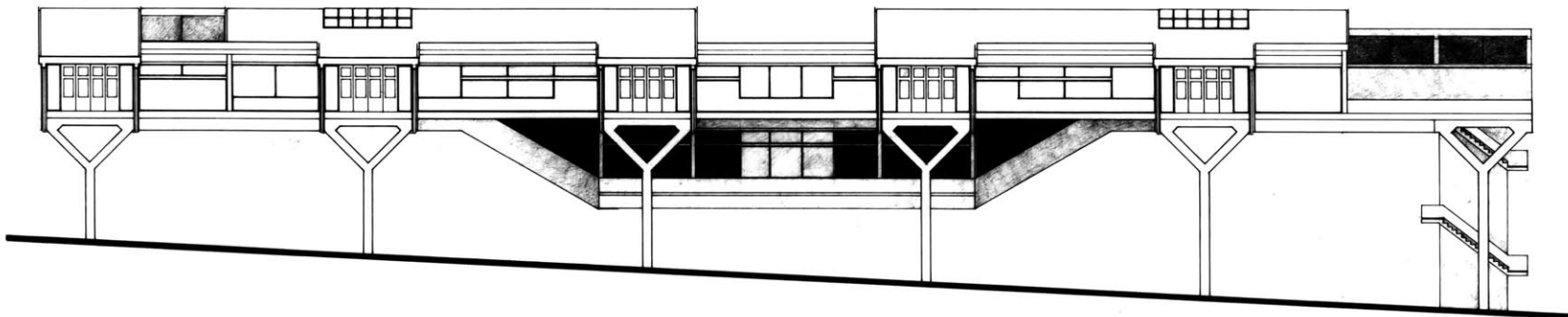
PEDESTRIAN CROSSING PLAN

3

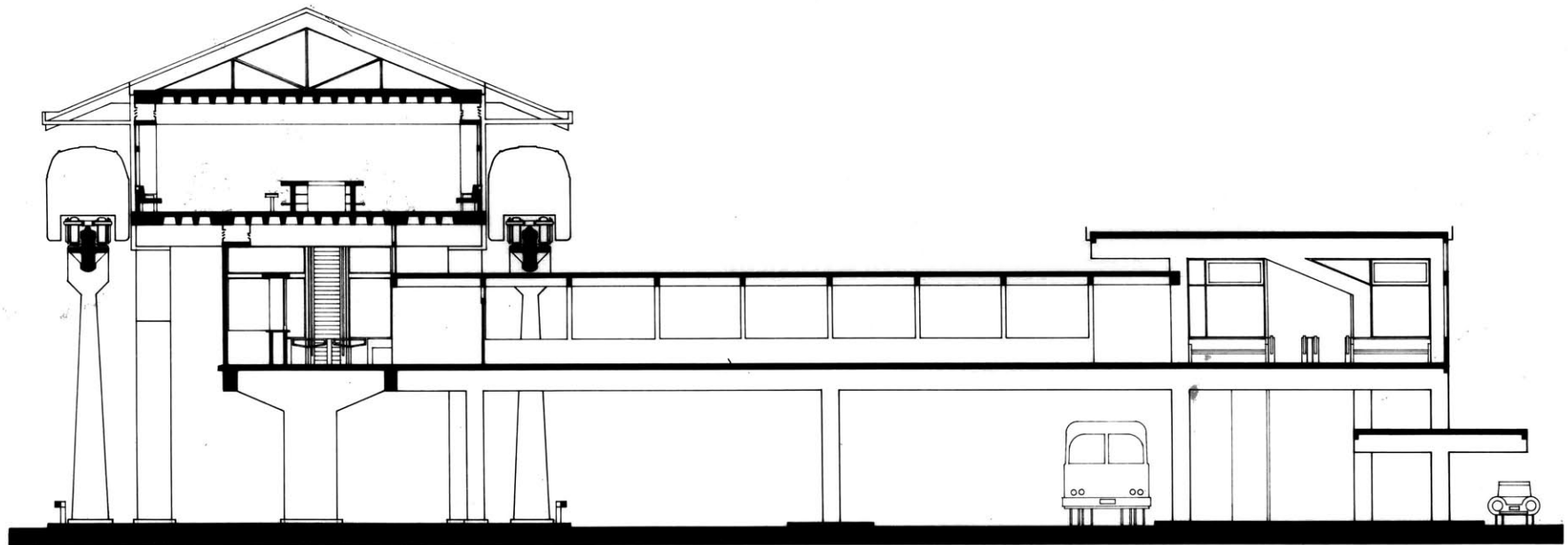
SCALE: 1/4" = 1'-0"



MONORAIL LEVEL PLAN



ELEVATION



CROSS SECTION

5

SCALE: 1/4" = 1'-0"